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NOVEMBER

A MANUAL

OF

PRACTICAL HYGIENE

BY

EDMUND A. PARKES, M.D., F.R.S.

LATE PROFESSOR OF MILITARY HYGIENE IN THE ARMY MEDICAL SCHOOL; MEMBER OF THE GENERAL COUNCIL OF MEDICAL EDUCATION; FELLOW OF THE SENATE OF THE UNIVERSITY OF LONDON; EMERITUS PROFESSOR OF CLINICAL MEDICINE IN UNIVERSITY COLLEGE, LONDON

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EDITED BY

F. S. B. FRANÇOIS DE CHAUMONT, M.D., F.R.S.

FELLOW OF THE ROYAL COLLEGE OF SURGEONS OF EDINBURGH; FELLOW AND CHAIRMAN OF COUNCIL OF THE SANITARY INSTITUTE OF GREAT BRITAIN; PROFESSOR OF MILITARY HYGIENE IN THE ARMY MEDICAL SCHOOL

SIXTH EDITION

WITH AN APPENDIX

GIVING THE AMERICAN PRACTICE IN MATTERS RELATING TO HYGIENE

PREPARED BY AND UNDER THE SUPERVISION OF

FREDERICK N. OWEN

CIVIL AND SANITARY ENGINEER

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Book I. (CONTINUED).

CHAPTER IX.

HABITATIONS.

Whoever considers carefully the record of the mediæval epidemics, and seeks to interpret them by our present knowledge of the causes of disease, will surely become convinced that one great reason why those epidemics were so frequent and so fatal was the compression of the population in faulty habitations. Ill-contrived and closely packed houses, with narrow streets, often made winding for the purpose of defence; a very poor supply of water, and therefore a universal uncleanliness; a want of all appliances for the removal of excreta; a population of rude, careless, and gross habits, living often on innutritious food, and frequently exposed to famine from their imperfect system of tillage,—such were the conditions which almost throughout the whole of Europe enabled diseases to attain a range, and to display a virulence, of which we have now scarcely a conception. The more these matters are examined, the more shall we be convinced that we must look, not to grand cosmical conditions; not to earthquakes, comets, or mysterious waves of an unseen and poisonous air; not to recondite epidemic constitutions, but to simple, familiar, and household conditions, to explain the spread and fatality of the mediæval plagues.

SECTION I.

GENERAL CONDITIONS OF HEALTH.

The diseases arising from faulty habitations are in great measure, perhaps entirely, the diseases of impure air. The site may be in fault; and from a moist and malarious soil excess of water and organic emanations may pass into the house. Or ventilation may be imperfect, and the exhalations of a crowded population may accumulate and putrefy; or the excretions may be allowed to remain in or near the house; or a general uncleanliness, from want of water, may cause a persistent contamination

of the air. And, on the contrary, these five conditions insure healthy habitations :—

1. A site dry and not malarious, and an aspect which gives light and cheerfulness.
2. A system of ventilation which carries off all respiratory impurities.
3. A system of immediate and perfect sewage removal, which shall render it impossible that the air shall be contaminated from excreta.
4. A pure supply and proper removal of water; by means of which perfect cleanliness of all parts of the house can be insured.
5. A condition of house construction which shall insure perfect dryness of the foundation, walls, and roof.

In other words, perfect purity and cleanliness of the air are the objects to be attained. This is the fundamental and paramount condition of healthy habitations; and it must override all other conditions. After it has been attained, the architect must engraft on it the other conditions of comfort, convenience, and beauty.

The inquiries which have been made for the last forty years in England have shown how badly the poorer classes are lodged, both in town and country, and how urgent is the necessity for improvement. Various Acts[1] have been passed for the purpose of improving laborers' cottages and other small dwellings, but either from the powers being insufficient, or from the difficulty of proving that a dwelling is injurious to health, unless it is in extremely bad condition, these Acts have had only partial effect.

Up to a certain point, there is no difficulty in insuring that a small house shall be as healthy as a large one. The site and foundations can be made as dry, the drains as well arranged, the walls and roofs as sound, and the water supply as good as a house of much larger rental. In fact, in one respect, the houses of the poor are often superior to those of the rich, for the sewers do not open directly into the houses, and sewer air is not breathed during the night. But the difficulty in the houses of the poor is the overcrowding, and the impregnation of the walls with foul effluvia and deposits. Considerations of cost will probably always prevent our poor class of houses from having sufficient floor and cubic space. These two special difficulties must be met by improved means of warming and ventilation, and by covering the interior walls with a cement which is non-absorbent, and which can be washed. Perhaps, also, improvements in using concrete, or other plans, will eventually so lessen the cost of building that larger rooms can be given for the same rental, and the poor be taught to prize the boon of an abundant allowance of air, and not seek to lessen it by crowding and underletting.

Dryness of the foundation and walls of a house is secured by draining the subsoil, 4 to 9 feet below the foundation,[2] and, in very wet clay soil, by paving or cementing under the entire house.[3] The walls are kept dry by being embedded in concrete, which is brought up to the ground level, or by the insertion in the walls themselves of a waterproof course of slate,

[1] Laboring Classes Dwelling-house Act, 1866; An Act to provide better Dwellings for Artisans and Laborers, 1868; Artisans Dwellings Act, 1875; various clauses in the different Public Health Acts.

[2] Even the walls of old rickety cottages may be thoroughly dried by this means (Rogers Field).

[3] For a good diagram of a plan for avoiding damp, see Bailey Denton's Sanitary Engineering, Plate L., p. 56.

asphalt, or, what is better, of ventilating vitrified thin bricks (as devised by Mr. Taylor).

On wet damp soils, when a house has no cellar, the flooring ought to be raised 2 feet above the ground, and the space below should be well ventilated. In the tropics, the houses are often raised on arches 3 to 5 feet above the ground. If this plan were universal, it would vastly improve the health of the community. Dryness of walls is best secured by hollow walls,[1] or coating the walls with cement, which is kept painted, or with slates. Terra-cotta slabs have been used, and liquid preparations (chiefly alkaline silicates) have been brushed over the surface of brick and stone. Bricks are often extremely porous,[2] and a brick wall will absorb many gallons of water.[3]

Dryness of the roof should be carefully looked to in every case, as water often gets to the walls through a bad roof, and the whole house becomes damp.

The condition of the basements or cellars, if they exist, requires attention, as the air of the house is often drawn directly from them. They should be dry, and thoroughly well ventilated, and the house pipes, if they run down to the basement, should be always uncovered so as to be easily inspected, and any bad-fitting joint, or crack, or imperfect trap, if there be one inside the house, be at once remedied.

The carrying off of rain water, so as not to sink into the ground near the house, is a matter of importance.

The other points which are necessary to secure a healthy house are discussed in their respective chapters.

In examining a house to discover the sources of unhealthiness, it is best to begin at the foundation, and to consider first the site and basements, then the living and sleeping rooms (as to size, cubic contents, and number of persons, and condition of walls and floors), ventilation, water supply, and plans of waste and sewer-water removal, in regular order.

The following memorandum as to the way in which engineers examine a house has been kindly furnished by Mr. William Eassie, C.E. :—

MEMORANDUM.

What is usually done by Sanitary Engineers when inspecting a House.

Sanitary engineers consider that an unusual smell is generally the first evidence of something wrong, and that, traced to its source, the evil is half cured. They inspect first the drainage arrangements. If the basement generally smells offensively, they search for a leaking drain-pipe, *i.e.*, a pipe badly jointed or broken by settlement, and these will often show themselves by a dampness of the paving around. If, upon inquiry, it turns out that rats are often seen, they come to the conclusion that the house drain is in direct communication with the sewer, or some old brick barrel-drain,

[1] Jenning's patent Bonding Brick is a good plan for preventing moisture penetrating from the outer to the inner skin of a hollow wall. It is a hollow, vitrified brick, curved upward at an angle of 45°, so that no water can pass along it.

[2] An ordinary brick will hold about 16 oz. of water.

[3] Bricks imperfectly burned on the outside of the kiln are termed Place, or Samel, or Sandel bricks. They absorb much water. The sun-dried bricks of India are very damp, and absorb water from the air. Many sandstones are very porous ; water beats into them and rises high by capillary attraction. Lime made from chalk absorbs water. Pisé is compressed earth, and, unless covered with cement, is moist.

and therefore examine the traps and lead bends which join the drain-pipes to see if they are gnawed or faulty. If the smell arises from any particular sink or trap, it is plain to them that there is no ventilation of the drain, and more especially no disconnection between the house and the sewer, or no flap-trap at the house-drain delivery into the sewer. If a country house be under examination, a smell at the sink will, in nearly every case, be traced to an unventilated cesspool; and, in opening up the drain under the sink, in such a state of things, they will take care that a candle is not brought near, so as to cause an explosion. If the trap is full of foul black water, impregnated with sewer air, they partly account for the smell by the neglect of flushing. If the sink, and kitchen, and scullery wastes are in good order and the smell is still observable, they search the other cellar rooms, and frequently find an old floor-trap without water, broken and open to the drain. If the smell be ammoniacal in character, they trace the stable-drains and see if they lead into the same pit, and if so, argue a weak pipe on the route, especially if, as in some London mansions, the stable-drains run from the mews at the back, through the house to the front street sewer.

Should a bad persistent smell be complained of mostly in the bedroom floor, they seek for an untrapped or defective closet, a burst soil-pipe, a bad junction between the lead and the cast-iron portion of the soil-pipe behind the casings, etc., or an improper connection with the drain below. They will examine how the soil-pipe is jointed there, and, if the joint be inside the house, will carefully attend to it. They will also remove the closet framing, and ascertain if any filth has overflowed and saturated the flooring, or if the safe underneath the apparatus be full of any liquid. If the smell be only occasional, they conclude that it has arisen when the closet handle has been lifted in ordinary use or to empty slops, and satisfy themselves that the soil-pipe is unventilated. They, moreover, examine the bath and lavatory waste-pipes, if they are untrapped, and if trapped by a sigmoidal bend, whether the trapping water is not always withdrawn owing to the siphon action in the full running pipe. They will trace all these water-pipes down to the sewer, ascertain if they wrongly enter the soil-pipe, the closet-trap, or a rain water-pipe in connection with the sewer.

If the smell be perceived for the most part in the attics, and, as they consider, scarcely attributable to any of the foregoing evils, they will see whether or not the rain water pipes which terminate in the gutters, are solely acting as drain ventilators, and blowing into the dormer windows. They will also examine the cisterns of rain water, if there be any in the other portions of the attics, as very often they are full of putridity.

A slight escape of impure air from the drains may be difficult to detect, and the smell may be attributed to want of ventilation, or a complication of matters may arise from a slight escape of gas. Neither are all dangerous smells of a foul nature, as there is a close sweet smell which is even worse. Should the drains and doubtful places have been previously treated by the inmates to strongly smelling disinfectants, or the vermin killed by poison, the inspectors of nuisances will find it difficult to separate the smells. In such a case, however, they will examine the state of the ground under the basement flooring, and feel certain that there are no disused cesspools or any sewage saturation *of any sort*. They will also ascertain if there be any stoppage in the drain-pipes, by taking up a yard trap in the line of the drain march, and noting the reappearance of the lime water which they had thrown down the sinks. And invariably, after ef-

fecting a cure for any evil which has been discovered, they will leave the traps cleaned out and the drains well flushed.

A thoroughly drained house has always a disconnection chamber placed between the house drain and the sewer or other outfall. This chamber is formed of a raking siphon, and about two feet of open channel pipe, built around by brickwork and covered by an iron man-hole. Fresh air is taken into this chamber by an open grating in the man-hole, or by an underground pipe, and the air thus constantly taken into the chamber courses along inside the drain, and is as continuously discharged at the ventilated continuations of the soil-pipes, which are left untrapped at the foot, or at special ventilating pipes at each end of the drain. This air current in the drain prevents all stagnation and smell.

When a house is undergoing examination, it is wise to test for lighting gas leakages, and there is only one scientific method of doing so, which is as follows :—Every burner is plugged up, save one, and to that is attached a tube in connection with an air force-pump and gauge—the meter having been previously disconnected. Air is then pumped into the whole system of pipes, and the stop-cock turned, and if, after working the pump for some time, and stopping it, the gauge shows no sign of sinking, the pipes may be taken as in safe condition ; but if the mercury in the gauge falls, owing to the escape of air from the gas-tubes, there is a leak in them, which is discoverable by pouring a little ether into the pipe close by the gauge, and recommencing pumping. Very minute holes can be detected by lathering the pipes with soap and water, and making use of the pump to create soap bubbles.

Besides the drainage, they will, especially if they detect a bad and dank smell, see if it arises from the want of a damp-proof course or of a dry area, see if there be a wet soil under the basement floor, a faulty pipe inside the wall, an unsound leaden gutter on the top of the wall, or an overflowing box gutter in the roof, a leaky slatage, a porous wall, a wall too thin, and so on.

They will also keep an eye upon the condition of the ventilating arrangements, and whether the evils complained of are not mainly due to defects there. The immediate surroundings of the house will also be noted, and any nuisances estimated.

Sanitary inspectors, whilst examining into the condition of the drains, always examine the water cisterns at the same time, and discover whether the cistern which yields the drinking water supplies as well the flushing water of the closets. They will also ascertain if the overflow pipe of this cistern, or of a separate drinking water cistern, passes directly into the drain.

If the overflow pipe be siphon-trapped and the water rarely changed in the trap, or only when the ball-cock is out of order, they will point out the fallacy of such trapping ; and, speaking of traps generally, they will look suspiciously on every one of them, endeavor to render them supererogatory by a thorough ventilation and disconnection of the drains.[1]

[1] Much useful information will also be obtained from Sanitary Arrangements for Dwellings, by W. Eassie, C.E., and from Sanitary Engineering, by J. Bailey Denton, C.E. See also The Habitation in Relation to Health, by F. de Chaumont, Christian Knowledge series; Our Homes, and how to keep them Healthy, Cassell, Petter & Galpin.

SECTION II.

HOSPITALS.

General Remarks.

Of late years a great number of works (English, French, German, and American) have been written on the construction of hospitals. This has been especially owing to the celebrated *Notes on Hospitals*, published by Miss Nightingale, after the Crimean war—a work the importance of which it is impossible to over-rate—and to the very useful pamphlets of Mr. Roberton, of Manchester. Among military writers, Robert Jackson in this, as in all other points, takes the first rank, and his observations on the construction of hospitals are conceived entirely in the spirit of the best writings of the present day. In the short space which can be given to the subject here, we can merely condense what has been best said on the subject, as applied especially to military hospitals.[1] In the first place, however, a few words are necessary on the general question.

Although the establishment of hospitals is a necessity, and marks the era of an advanced civilization, it must always be remembered that if the crowding of healthy men has its danger, the bringing together within a confined area many sick persons is far more perilous. The risks of contamination of the air, and of impregnation of the materials of the building with morbid substances, are so greatly increased, that the greatest care is necessary that hospitals shall not become pest-houses, and do more harm than good. We must always remember, indeed, that a number of sick persons are merely brought together in order that medical attendance and nursing may be more easily and perfectly performed. The risks of aggregation are encountered for this reason ; otherwise it would be far better that sick persons should be separately treated, and that there should be no chance that the rapidly changing, and in many instances putrefying substances of one sick body should pass into the bodies of the neighboring patients. There is, indeed, a continual sacrifice of life from diseases caught in, or aggravated by hospitals. The many advantages of hospitals more than counterbalance this sacrifice, but it should be the first object to lessen the chance of injury to the utmost. The risk of transference or aggravation of disease is least in the best ventilated hospitals. A great supply of air, by immediately diluting and rapidly carrying away the morbid substances evolved in such quantities from the bodies and excretions of the sick, reduces the risk to its minimum, and perhaps removes it altogether. But the supply of air must be enormous ; there must be a minimum of not less than 4,000 cubic feet per head per hour for ordinary cases ; and the supply must be practically unlimited for the acute and febrile diseases.

The causes of the greater contamination of the air of hospitals are these :—

[1] For fuller details, Captain Galton's work on Hospitals should be consulted. See also Five Essays on Hospital Plans, contributed for the Johns Hopkins Hospital Scheme (Wood & Co., New York); Report on the Manchester Royal Infirmary, by J. Netten Radcliffe, Esq. ; Reports on St. Mary's Hospital, Paddington, by F. de Chaumont, M.D ; chapter in Roth and Lex, Milit. Gesundheitspflege ; paper in the Practitioner, March, 1877 ; article "Hospital," Encyclopædia Britannica, 9th edition ; Das Allgemeine Krankenhaus der stadt Berlin im Friedrichshain, von A. Hagemeyer, Berlin, 1879.

1. More organic effluvia are given off from the bodies and excretions of sick men. These are only removed by the most complete ventilation.

2. The medical and surgical management of the sick necessarily often exposes to the air excretions, dressings, foul poultices, soiled clothes, etc., and the amount of substances thus added to the air is by no means inconsiderable, even with the best management.

3. The walls and floors of hospitals absorb organic matters and retain them obstinately, so that in some cases of repeated attacks of hospital gangrene in a ward it has been found necessary to destroy even the whole wall. Continual drippings on the floor of substances which soak into the boards and through crevices, and collect under the floor, also occur, and thus collections exist of putrefying matters which constantly contaminate the air.

4. The bedding and furniture also absorb organic substances, and are a great cause of insalubrity.

5. Till very recently, even in the best hospitals, the water-closets and urinals were badly arranged, and air passed from these places into the wards.

In addition to the necessary amount to dilute and remove these substances, the freest supply of air is also now known to be a curative means of the highest moment; in the cases of the febrile diseases, both specific and symptomatic, it is indeed the first essential of treatment; sometimes, especially in typhus and small-pox, it even lessens duration, and in many cases it renders convalescence shorter.[1]

There can be no doubt, that the necessity for an unlimited supply of air is the cardinal consideration in the erection of hospitals, and, in fact, must govern the construction of the buildings. For many diseases, especially the acute, the merest hovels with plenty of air are better than the most costly hospitals without it. It is ill-judged humanity to overcrowd febrile patients into a building, merely because it is called a hospital, when the very fact of the overcrowding lessens or even destroys its usefulness. In times of war, it should never be forgotten by medical officers that the rudest shed, the slightest covering, which will protect from the weather, is better than the easy plan so often suggested and acted on, of putting the beds a little closer together.

The recognition that the ample supply of pure air is the first essential of a good hospital, led Miss Nightingale to advocate with so much energy and success the view which may be embodied in the two following rules:—

1. The sick should be distributed over as large an area as possible, and each sick man should be as far removed as possible from his neighbor.

2. The sick should be placed in small detached and perfectly ventilated buildings, so that there should be no great number of persons in one building, and no possibility of the polluted air of one ward passing into another.

How is this perfect Purity of Air to be secured?

This is a matter partly of construction, partly of superintendence.

(*a*) There should be detached buildings, so disposed as to get the freest air and the greatest light. They should be at considerable distances apart, so that 1,000 sick should be spread like a village; and in the wards each

[1] For examples of the value of a great supply of fresh air on some diseases, see note in former editions of this work.

man ought to have not less than 100, if possible 120, feet of superficial, and from 1,500 to 2,000 feet of cubic space. With detached buildings, the size of a hospital, as pointed out by Miss Nightingale, is dependent merely on the facility of administration. When the hospitals consist of a single building the smallest hospitals are the best.

(*b*) The ventilation should be natural, *i.e.*, dependent on the movement of the outer air, and on inequalities of weight of the external and internal air. The reason of this is, that a much more efficient ventilation can be obtained at a cheaper cost than by any artificial means. Also, by means of open doors and windows, we can obtain at any moment any amount of ventilation in a special ward, whereas local alterations of this kind are not possible in any artificial system. The amount of air, also, which any artificial system can cheaply give is comparatively limited. The amount of air should be restricted only by the necessity of not allowing its movement to be too perceptible.

The best arrangements for natural ventilation for hospitals appear to be these—1st. Opposite windows reaching nearly to the ceiling, on the sides of a ward (not wider than 24 feet, and containing only two rows of beds) and a large end window. 2d. Additional openings, to secure, as far as possible, a vertical movement of the air from below upward; and this will be best accomplished as follows:[1]—

A tube opening at once to the external air should run transversely along the floor of the ward to each bed, and should end in a box placed under the bed, and provided with openings at the top and sides, which can be more or less closed. In the box, coils of hot-water pipes should be introduced to warm the air when necessary. The area of the tube should not be less than 72 square inches to each bed; and the area of the openings in the box at least four times larger. The fresh air, warmed to any degree and moistened, if necessary, by placing wet cloths in the box, or medicated by placing chlorine, iodine, or other substances, will then pass under each bed, and ventilate that space so often unaired; and then, ascending round the sides of the bed, will at once dilute and carry up the products of respiration and transpiration to the ceiling. It would be a simple matter so to arrange the hot-water pipes as to be able to cut off all or some of the pipes under a particular bed from the hot-water current if desired, and so to give a fever patient air of any temperature, from cold to hot, desired by the physician. In the low and exhausted stages of fever warm air is often desirable. By this simple plan, we could deal more effectually with the atmosphere round our patients, as to warmth, dryness, humidity, and medication, than by any other. At the same time, the open fireplace and chimney, and the open doors and windows, might be preserved.[2]

For the exit of the foul air, channels in the ridge should be provided, warmed by gas if possible.

To facilitate this system of ventilation, it is desirable to have the buildings one-storied only; but it can be applied with two stories. Only then the discharge tubes must be placed at the sides, and run up in the thickness of the walls.[3]

[1] A plan similar to this has been devised by Dr. S. Hale, and adopted in some of the Australian hospitals. It is an excellent arrangement, but seems rather unnecessarily complicated by taking the air under the floor, and elevating the beds on a dais.

[2] The introduction of vertical tubes is also useful, as giving the air an upward direction and allowing a considerable supply without draughts.

[3] When the ceiling is flat the outlets may be advantageously placed at the sides close to the ceiling, but with a one-storied or upper ward an open roof is better.

But not only should there be good ventilation, but the wards ought to be every year empty for two or three weeks, and during the time thoroughly exposed to the air, every door and window being open.

(*c*) The strictest rules should be laid down with regard to the immediate removal from the wards of all excreta, dirty dressings, foul linen, etc. Nothing that can possibly give off anything to the air should be allowed to remain a single moment. Dressings of foul wounds should be sprinkled with deodorants.

(*d*) The walls should be of impermeable material. Cements of different kinds are now used, especially Parian; large slabs of properly colored tiles, joined by a good cement, and good Portland cement well painted, would, however, be better. Parian cracks and spaces form behind it. Ceiling should be either cemented or frequently limewashed. Great care should be taken with the floors. On the whole, good oak laid on concrete seems the best material; but the joinings should be perfect, so that no fluid may pass through and collect below the floor. Possibly it might be well to cover the floor with a good oil-cloth, or material of the like kind, which would prevent substances from sinking into the boards, and would lessen the necessity of washing the floors, but might be itself removed, and



FIG. 69.—Ward for Twenty Ward-beds. A, ward; B, nurse's-room, with ward-window; C, scullery; D, water-closet and ward-sink; E, bath-room and ablution-room; F, ventilated lobbies.

frequently washed. The practice of waxing and dry-rubbing the floors, and other similar plans, is intended to answer the same purpose. Dr. Langstaff, of Southampton, strongly recommends solid paraffin. The paraffin is melted and then poured on the floor, and ironed into it with a box-iron, heated from the interior by burning charcoal; it penetrates about a quarter of an inch into the wood. The excess of paraffin is scraped off, and the floor is brushed with a hard brush; a little paraffin in turpentine is then put on, and the flooring is good for years.[1]

(*e*) The furniture in a ward should be reduced to the minimum; and as far as possible, everything should be of iron. The bedding should also be reduced in size, as much as can be. Thick mattresses should be discarded, and thin mattresses, made easy and comfortable by being placed on springs, employed.[2] The material for mattresses should be

[1] An experience of some years in the Southampton Infirmary has proved the advantage of this flooring. It has also been introduced with satisfactory results into the Bristol Infirmary, according to information received from Mr. Eassie, C.E.

[2] The wire mattress bedstead, as arranged by Dr. Reed, in use in the Manchester Royal Infirmary, and made by Messrs. Chorlton & Dugdale, seems an excellent and very comfortable form.

horse-hair (18 lb weight to each mattress), or coir fibre, which, on the whole, are least absorbent. Straw, which absorbs very little, is bulky, and is said to be cold. All flock and woollen mattresses should be discarded. Blankets and coverlets should be white or yellowish in color, and should be frequently thoroughly aired, fumigated, and washed.

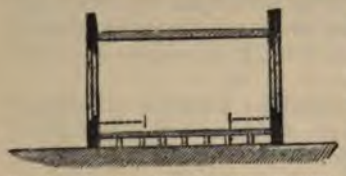


FIG. 70.—Section of Ward to show the Bed.

(*f*) The arrangement of the water-closets and urinals is a matter of the greatest moment. Every ward should have a urinal, so that the common practice of retaining urine in the utensils may be discontinued. If the urine is kept for medical inspection, it should be in closed vessels. The removal of excreta must be by water. In hospitals, nothing else can be depended upon, as regards certainty and rapidity. The best arrangement for closets is not the handle and plug, which very feeble patients will not lift; but a self-acting water supply connected with the door, and flowing when it is open. This plan is better than the self-acting spring seat,

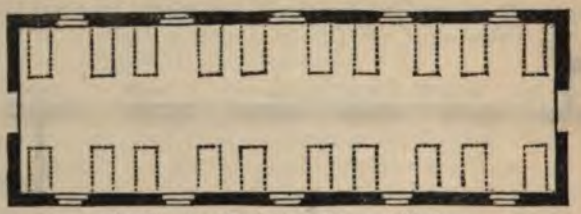


FIG. 71.—Drawing to show Beds and Windows.

which is not always easily depressed by a thin patient; and also, by leaving the open door, it gives us the means of pouring in any quantity of water, and of thoroughly flushing the pan and pipe. The closets are best arranged in nearly detached lobbies, at one end of the ward, and separated from it by a thorough cross ventilation, as shown in the plan which is copied from Miss Nightingale's work.[1] A further improvement may be made by throwing the closets still further out, with an intercepting lobby, as shown in Fig. 72.



FIG. 72.—Closets (W. C.) and Lavatory (L.) with intervening ventilated lobbies (*l*).

In this way, provided the site of the hospital is originally well chosen, perfect purity of air can be obtained, and the first requisite of a good hospital is secured.

Next to the supply of pure air, and to the measures for preventing contamination (which embrace construction, ventilation, cleanliness, and latrine arrangements), come the arrangements for medical treatment.

Medical treatment includes—

1. *Supply of Food.*—The diet of the sick is now becoming a matter of scientific precision; and it is probable that every year greater and greater importance will be attached to it. Hence the necessity of a perfect central kitchen, and of means for

[1] Dr. Buchanan has suggested a plan of vertical ventilation in the vestibule, in cases where cross ventilation is not available. This, of course, need not to be in a new building, although it might be useful in the adaptation of an existing one. The addition of a slop sink, for the emptying of bed-pans, etc., would also be useful.

the rapid supply of food at all times. There is more difficulty in doing this than at first appears, as the central kitchen cannot supply everything; and yet there must be no cooking in the wards, or even near them, as the time of the attendants should be occupied in other ways. Probably the best arrangement is to have hot closets close to the wards, where the food sent from the kitchen can be kept warm, and ready for use at all hours of the day and night.

2. *The Supply of Water.*—Hot and cold water must be supplied everywhere, and baths of all kinds should be available. The supply of water for all purposes should be 40 to 50 gallons per head daily.

3. *The Supply of Drugs and Apparatus.*—The chief point is to economize the time of attendants, and to enable drugs and apparatus to be procured without delay when needed.

4. *The Nursing and Attendance, including the Supply of Clean Linen, etc.*—The time and labor of the attendants should be expended, as far as possible, in nursing, and not in other duties. Every contrivance to save labor and cleaning should therefore be employed. Lifts, shafts, tramways, and speaking-tubes to economize time; wards arranged so as to allow the attendants a view of every patient; wards not too large nor too small, for Miss Nightingale has conclusively shown that wards of from 20 to 32 beds are best suited for economy of service.

5. *Means of Open-air Exercise for Patients.*—This ought properly to be considered as medical treatment. As soon as a patient can get out of his ward into the open air he should do so; therefore, open verandas on the sunny sides of the wards, and sheltered gardens, are most important. For the same reason hospitals of one story are best,[1] as the patients easily get out; if of two stories, the stairs should be shallow.

6. In addition to all these, the supply of air medicated with gases, or fine powders, or various amounts of watery vapor, is a mode of treatment which is sure to become more common in certain diseases, and special wards will have to be provided for these remedies.

The parts of a military hospital are[2]—

Patients' Rooms, Wards, and Day-rooms, if possible; the wards of two sizes,—large, *i.e.*, from 20 to 32 beds, and small, for one or two patients. It is desirable to have the small wards not close to the large ones, but at some little distance. Attached to the wards are attendants' rooms, scullery, bath and ablution rooms, small store-room, urinal, closets (one seat to every eight men).

Operating-room—Dead-house—Administration.—Surgeons' rooms; case-book and instrument room; offices and officers' room.

Pharmacy.—Dispensary; store-room; dispenser's room.

[1] The late Dr. Parkes wrote:—"I had never properly estimated the importance of patients getting into the air, and the desirability of one-storied buildings for this purpose, till I served at Renkioi, in Turkey, during the Crimean war. The hospital was composed of one-storied wooden houses connected by an open corridor. As soon as a man could crawl he always got into the corridor or between the houses, and the good effects were manifest. Some of the medical officers had their patients' beds carried out into the corridor when the men could not walk. In the winter greatcoats were provided for the men to put on, and they were then encouraged to go into the corridor."

[2] Hospital space is to be provided for 10 per cent. of the force. Lately, since the health of the army has been so much improved on home service, it has been proposed to reduce it to 7 per cent., but it would appear desirable always to have a large hospital space for emergencies and for war. For the duties of administrative medical officers with regard to hospitals, see the Medical Regulations, 1878.

Culinary.—Store-room ; wine and beer room ; larder and meat room ; kitchen ; room for arranging diets ; scullery ; cook's room.

Washing.—Washhouse ; dirty linen store ; baking and fumigating room ; cleaning room for mattresses.

Steward's Department.—Offices, furniture, linen, utensil, and pack stores ; rooms for cleaning.

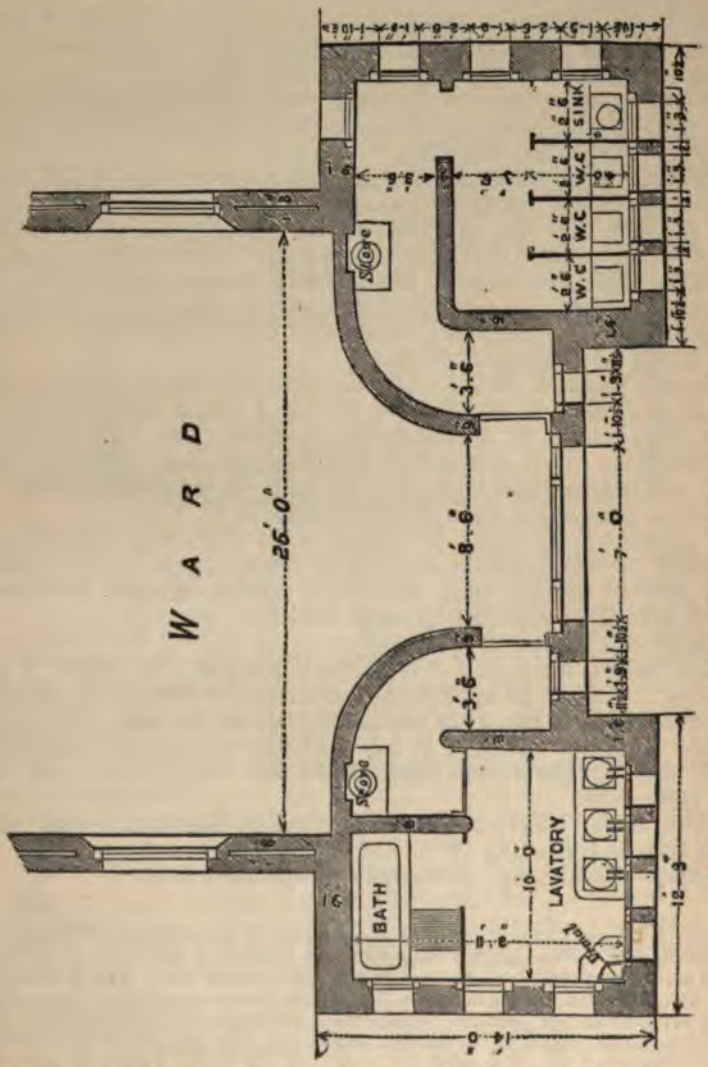


FIG. 73.—Detail of present Ward, Lavatory, Closets, and Urinal, as used in Military Hospitals (from Miss Nightingale's book).

The amount for storage room is, for an hospital of 100 sick—

Bedding and store	= 200 square feet.	Fuel store	= 250 square feet.
Clothing store	= 100 "	Foul linen store	= 120 "
Utensil store	= 160–200 "	Pack store	= 200 "
Provision store	= 100 "	(In military hospitals.)	

Fig. 73 shows the arrangement of closets and lavatory in a military hospital.

The two following plans show the arrangement of the Lariboisière Hospital in Paris,[1] which circumstances have made the type of the so-called block or pavilion plan; and of the Herbert Hospital, which is the best military hospital in this country, or perhaps anywhere.

The Herbert Hospital at Woolwich consists of four double and three single pavilions of two floors each, all raised on basements. There is a convalescents' day-room in the centre pavilion. The administration is in a separate block in front. The axis of the wards is a little to the east of north. There is a corridor in the basement, through which the food, medicines, coals, etc., are conveyed, and then, by a series of lifts, elevated to the wards. The terraces in the corridor afford easy means of open-air exercise for the

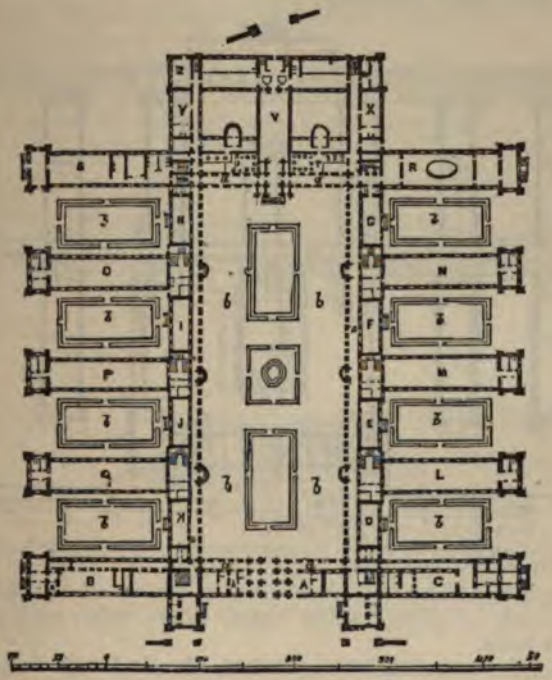


FIG. 74.—Lariboisière Hospital at Paris.

patients in the upper ward. The wards are warmed by two central open fire-places, with descending flues, round which are air-passages, so that the entering air is warmed. The floors are iron beams, filled in with concrete, and covered with oak boarding.[2]

The usual shape of ward is oblong, the standard width 26 feet (in the army) to 30 feet (St. Thomas's, for instance), and the length being determined by the number of beds. Mr. John Marshall[3] has, however, advocated a system of circular wards, which he thinks have certain advantages,

[1] The new Hôtel-Dieu is on the same general plan.

[2] The arrangement of the pavilions may be varied in many ways; for different forms of arrangement, see the works already cited. It has been thought unnecessary to take up space by inserting plans, which vary merely in detail.

[3] On a Circular System of Hospital Wards, by John Marshall, F.R.S., etc. London, Smith & Elder, 1878.

and a similar plan has been actually carried out in the new hospital at Antwerp, which will probably be ready for occupation by the end of this year (1882).[1]

Hospitals in the Tropics.

The Barrack and Hospital Commission, in carrying out the plans of the Royal Indian Sanitary Commission, suggest[2] for each sick man—

Superficial area = 100 square feet, up to 120 in unhealthy districts.

Cubical space = 1,500 feet, or, in unhealthy districts, 2,000 feet.

It is also directed that hospitals should consist of two divisions—1st, for sick ; and 2d, for convalescents. This latter division to hold 25 per cent. of the total hospital inmates.

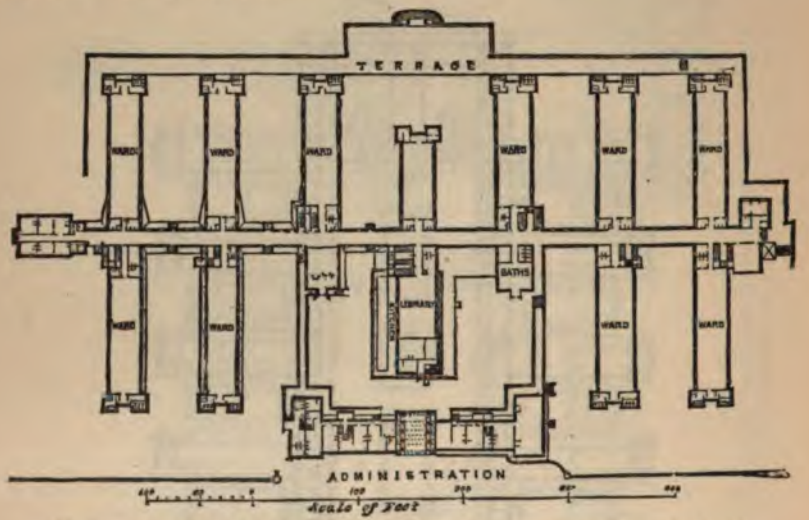


FIG. 75.—Ground Plan of the Herbert Hospital, Woolwich (from Miss Nightingale's book).

Each hospital is to be built in blocks, to consist of two floors, the sick and convalescents to sleep on the upper floors only; each block to hold only 20 to 24 beds.

The principles and details are, in fact, identical with those already ordered for the home stations.

Hospitals for Infectious Diseases.

Fever and small-pox hospitals have been long established in many large English towns ; but within the last few years it has become usual for all towns of any size to put up some temporary hospitals during an outbreak of cholera, small-pox, relapsing fever, and typhus, and to remove persons ill with these diseases at once from their dwellings. In this way, if there is early discovery of the cases, the chances of spread of the disease are greatly lessened.[3]

[1] British Medical Journal, August 26, 1882, on p. 350 a ground plan is given ; see also London Medical Record, July 15, 1881, p. 296 ; and Charitable and Parochial Establishments, by Saxon Snell, F.R.I.B.A., for similar plans.

[2] Op. cit., p. 27.

[3] That such hospitals may, however, be themselves centres of infection has been shown by the Report of the Hospitals Commission, 1882, which may be consulted for much valuable information.

The Medical Department of the Privy Council issued a Memorandum in 1872,[1] pointing out that power is given under the 37th section of the Sanitary Act, 1866,[2] to the local board, improvement commissioners, town council, or vestry, to provide "hospitals or temporary places for the reception of the sick." It is pointed out that villages should have the means of accommodating instantly four cases of infectious disease in at least two separate rooms, and it is considered that a good cottage would answer this purpose. In towns a permanent provision is advised to be made, and the following suggestions are made :—The situation to be convenient; ward cubic space, 2,000 feet per head; ward floor-space per head, 144 square feet; good provision for ventilation; precautions against entrance of foul air (as from privies or sinks); warming in winter to 60° Fahr.; keeping cool in summer; means of disposal of excrements and slops; and for cleaning and disinfecting linen.

For temporary emergencies, tents (army hospital marquees) are recommended, or huts are advised. The huts are described at some length, and plans are given of the huts and of the arrangement. As these are very similar to those used by the army in war, reference is made to that section.

[1] Memorandum on Hospital Accommodation to be given by Local Authorities (signed John Simon, July 8, 1872).

[2] Now under the 131st and following clauses of the Public Health Act of 1875.

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CHAPTER X.

REMOVAL OF EXCRETA.

We have seen that a regular supply of pure air—in other words, efficient ventilation—is required to remove the excreta of the lungs and the volatile products of the skin. The solid and fluid excreta from the bowels and the kidneys ought to be as rapidly and as completely removed as the gaseous impurities.

It is highly probable that to barbarous and inefficient modes of removing the excreta of men and of animals we must partly trace the great prevalence of disease in the middle ages, and there is no doubt that many of the diseases now prevailing in our large towns are owing to the same cause.

When men live in thinly populated countries, following, as they will then do, an agricultural or nomade life, they will not experience the consequences of insufficient removal of excreta. The sewage matter returns at once to that great deodorizer the soil, and fertilizing it, becomes a benefit to man, and not a danger. It is only when men collect in communities that the disposal of excreta becomes a matter literally of life and death, and before it can be settled the utmost skill and energy of a people may be taxed.

The question of the proper mode of disposal of sewage has been somewhat perplexed by not keeping apart two separate considerations. The object of the physician is to remove as rapidly as possible all excreta from dwellings, so that neither air, water, nor soil shall be made impure. The agriculturist wishes to obtain from the sewage its fertilizing powers. It is not easy to satisfy both parties, but it will probably be conceded that safety is the first thing to be sought, and that profit must come afterward.

SECTION I.

AMOUNT AND PRODUCTS OF THE SOLID AND FLUID EXCRETA.

Amount of the Solid and Fluid Excreta.

The amount of the bowel and kidney excreta vary in different persons and with different modes of life. On an average, in Europe, the daily solid excreta are about 4 ounces by weight, and the daily fluid excreta 50 ounces by measure for each male adult. Women and children pass rather less. Vegetable pass more solid excreta than animal feeders, but this is chiefly owing to a large proportion of water.[1] Taking all ages and both sexes into

[1] Mr. Fawcus's experiments on Bengalee prisoners give an average bowel excretion of 12 ounces, and in Bombay Dr. Hewlett found the alvine discharges to be quite as large.

consideration, we may estimate the daily amount per head of population in Europe at 2½ ounces of fæcal, and 40 ounces of urinary discharge. A population of 1,000 persons would thus pass daily 156 lb of solids and 260 gallons of urine, or in a year 25 tons of fæces, and 91,250 gallons (14,646 cubic feet) of urine. Letheby gives the mean amount per head as 2.784 ounces of fæces and 31.851 ounces of urine. In a mixed population of 1,000 persons of different sexes and ages, Letheby has calculated that the daily discharge of the whole town will be 2,266 lb avoir. of urine and 177.5 lb of fæces.

Frankland estimates the mean daily amount per head as 3 ounces of fæces and nearly 40 ounces by measure of urine. In adult males the quantity of nitrogen daily discharged by the bowels and kidneys amounts to from 250 to 306 grains, representing 304 and 372 grains of ammonia. Taking the whole population, however, the amount must be considerably less than this. Dr. Parkes calculated it as 153 grains of nitrogen, and Letheby gave it as 155.8 grains, or from 186 to 189 grains of ammonia, *i.e.*, the mean excretion of all the population is very nearly half the excretion of the adult male.

Decomposition of Sewage Matter.

Fresh healthy fæcal matter from persons on mixed diet, unmixed with urine, has an acid reaction, and this it retains for a considerable time; it then becomes alkaline from ammonia. If free from urine, it usually decomposes slowly, and in hot weather often dries on the surface, and subsequently changes but little for some time. The urine, when unmixed with fæcal matter, also retains its natural acidity for a variable number of days, sometimes three or four; sometimes eight or ten, or even longer, and then becomes alkaline from ureal decomposition. When the fæces and urine are mixed, the formation of ammonium carbonate from ureal decomposition is much more rapid; the solid excreta seem to have the same sort of action as the bladder mucus, and the mixed excreta become alkaline in twenty-four hours, while the separate excreta are still acid. And in its turn the presence of the urine seems to aid the decomposition of the solid matter, or this may be perhaps from the effect of the fluid, as pure water seems to act almost as rapidly as urine in this respect. Pappenheim[1] states that the absorption of oxygen by the fæces is greatly increased when urine is added. When the solid excreta and urine are left for two or three weeks, the mixture becomes usually extremely viscid, and this occurs, though to a less extent, when an equal quantity of pure water takes the place of urine. The viscidity is prevented by carbolic acid.

When the solid excreta (unmixed with urine) begin to decompose, they give out very fetid substances, which are no doubt organic; hydrogen sulphide is seldom detected, at any rate by the common plan of suspending paper soaked in lead solution above the decomposing mass. When heated, a large quantity of gas is disengaged, which is inflammable, and consists in great measure of carburetted hydrogen. When (instead of being dry) urine is present, ammonia and fetid organic matters are disengaged in large quantity. When water is also present, and if the temperature of the air is not too low, not only organic matters but gases are given out, consisting of light carburetted hydrogen, nitrogen, and carbon dioxide. Hydrogen sulphide can be also disengaged by heat, and is almost always

[1] Handb. der. San. Pol., 2d edit., Band i., p. 72.

found in the liquid, usually in combination with ammonia, from which it is sometimes liberated and then passes into the air.

SECTION II.

METHODS OF REMOVAL OF EXCRETA.

While all will agree in the necessity of the immediate removal of excreta from dwellings, the best modes of doing so are by no means settled. The fact is that several methods of removing sewage are applicable in different circumstances, and their relative amounts of utility depend entirely on the condition of the particular place.

The different plans may be conveniently divided into[1]—

1. The water method.
2. The dry methods.

Before noticing these plans, it will be convenient to make a few general observations on sewers.

Sewers.

Sewers are conduits employed to remove waste water and waste products suspended in water from houses, or to carry away rain. Among the waste products may be the solid and liquid excreta of men and animals, or the refuse of trade and factory operations. Or sewers may be used merely for the conveyance of dirty house water, without the admixture of excreta or trade refuse.

It is quite impossible that any town or even any single large house can be properly freed of its waste house water without sewers, and in a more or less perfect condition they are to be found not only in all modern, but in most ancient cities. Originally, no doubt, they were mere surface channels, as they are still in many towns; but for the sake of appearance and inoffensiveness, the custom must have soon arisen of placing them underground, nor in modern towns could they now be arranged otherwise. In some large towns there are even hundreds of miles of sewers, constructed often with great skill and science, and they serve in some instances as the channels not only for rain, but for natural streams which have been enclosed.

The sewers form thus in the subsoil of towns a vast network of tubes, connecting every house, and converging to a common outlet where their contents may be discharged.

In some towns the sewers carry away none of the solid excreta, though probably urine enters in all cases. In most towns, however, solid excreta, in greater or less quantity enter, owing especially to the prevalent use of water-closets, or to the drainage of middens and manure heaps.

Whether the solid excreta pass in or not, the liquid in the sewers must always contain either suspended or dissolved animal and vegetable matters derived from the refuse of houses. It is generally warmer than the water

[1] Dr. Corfield's work (A Digest of Facts relating to the Treatment and Utilization of Sewage, by W. H. Corfield, 2d edit., 1871) will be found to give a good summary of this subject. See also Report of a Committee appointed by the President of the Local Government Board to inquire into the several modes of treating Town Sewage, London, Eyre & Spottiswoode, 1876; see also "Die Menschliche Abfallstoffe," von Dr. Ferd. Fischer, Supplement zur Deutschen Viertelj. f. Offt. Gesundh., 1882.

of streams, and is of no constant composition; sometimes it is very turbid, and highly impure; in other cases it is hardly more impure than the water of surface wells. The suspended matters are, however, generally in larger proportion than the dissolved.

In some cases the sewer water is in greater amount than the water supplied to the town and the rainfall together. This arises from the subsoil water finding its way into the sewers.

One ton of London or Rugby sewage contains only from 2 lb to 3 lb of solid matter (Lawes).[1]

The average composition of sewer water in towns with water-closets is, organic matter, 27.72; nitrogen, 6.21; phosphoric acid, 1.57; potash, 2.03 grains per gallon.[2]

The Rivers Pollution Commissioners give 7.28 grains of organic nitrogen per 100,000 parts, or 5.41 grains per gallon; the mean amount of ammonia is 6.703 per 100,000, or 4.695 grains per gallon.

Under the microscope, sewer water contains various dead decaying matters, and in addition multitudes of *Bacteria* and amœbiform bodies, as well as some ciliated infusoria, especially *Paramecia*. *Fungi* (spores and mycelium) are seen, but there are few *Diatoms* or *Desmids*, and not many of the higher animals, such as *Rotifera*.

A controversy is still going on, whether the solid excreta ought to be admitted into the sewers. The point is virtually practically decided in many towns in this country by the general use of water-closets, which cannot now in these towns be superseded by any plan yet proposed. It is, however, quite an open question, whether, if all the arrangements could be commenced *de novo*, the admission of the solid excreta would be proper.

The arguments for and against this view will presently be stated.

Whether the solid excreta are allowed to pass in or not, it is clear that the dirty water of the sewers must in some way be disposed of. It is in every case more or less impure, containing animal and vegetable substances in a state of commencing decay, which passes readily into putrefaction. The readiest mode of getting rid of it is to pass it into streams, where it is at once subjected to the influence of a large body of water, and where the solid matters become either slowly oxidized, or form food for fishes or water plants, or subside. Although from an early period streams were thus contaminated and their water originally pure was thus rendered unfit for use, it is only lately that a strong opposition has arisen to the discharge into streams. This is owing partly to the greater pollution and nuisance caused by the more common use of water-closets and the largely increasing trade of the country, which causes more refuse to be sent in, and partly to the evidence which has been lately brought forward of the diseases which are caused by drinking water made impure in this way. To prevent the nuisance and danger caused by the pollution of streams, many actions at law have been brought, and in some cases special Acts of Parliament have forbidden the discharge of sewer water into certain rivers until after efficient purification. The Rivers Pollution Act of 1876 now deals with the question, its provisions having come into operation on August 15, 1877.

[1] For the composition of sewer water see Way, Second Report of Common Sewage of Towns, 1861, p. 69 et seq.; Letheby, The Sewage Question, 1872, p. 135; Report on Town Sewage, 1876; Rivers Pollution Commissioners' Report.

[2] Letheby, op. cit., p. 138.

Up to a certain point, there would probably be a general agreement as to the principle on which this difficult question should be dealt with. Animal substances in a state of decay can be best prevented from contaminating the air, the soil, or the water of streams, by imitating the operations of nature. In the endless cycle of physical change, decaying animal matters are the natural food of plants, and plants again form the food of animals.

It so happens that, with the exception of some mineral trades, the waste products of which are hurtful to agriculture, many of the substances contained in the sewer water of our towns are adapted for the food of plants, and we seem on sure ground when we decide that it must be correct to submit these matters to the action of plant life, and thus to convert them from dangerous impurities into wholesome food.

The difficulty is, however, with the application of the principle, and at the present moment there is the utmost diversity of opinion on this point. It seems, however, that we may divide the opinions into two classes. According to one opinion, the proper mode is to bring the waste water of towns, when it contains fertilizing matters, at once to the ground, and after the arrest of substances which may block the pipes, to pour it over the land in such a way as may be best adapted to free it from its impurities, and to bring it most rapidly and efficiently under the influence of growing plants.

The other opinion objects to this course on two grounds : first, that the substances are not brought to the ground in the most convenient form for agriculture, and also that the plan entails evils of its own, arising from the immense quantity of water brought upon the land and from the difficulty of efficient management. The advocates of this second view would, therefore, use some plan of separating the impurities of the water, and would then apply them in a solid form to the land, or use them for some other purpose, as in General Scott's plan of adding the materials for cement and then making this substance. The purified water would then be filtered through land, or passed into streams, without further treatment.

In the case of the sewage water containing materials not adapted for agriculture, both parties would deal with it in the same way, viz., purify it by chemical agencies or filtration, and then allow the water to flow off into streams, while the solid products would be disposed of in the most convenient way.

These general views apply to any sewer water, whether it contains solid excreta or not, although if these excreta can be perfectly excluded the sewer water is less offensive. It has hitherto been often poured into streams without previous purification, though now this practice is prohibited by law, with certain reservations.

The sewers of a town are for the most part used also to carry off the rainfall, and, indeed, before the introduction of water-closets, they were used only for this purpose, and for taking away the slop and sink water of houses. In countries with heavy rainfall, and in this country in certain cases, the rainfall channels are distinct from the sewers, and the outfalls may be in an entirely different direction. This is sometimes called the "separate system."

Removal of Excreta by Water.

This is the cleanest, the readiest, the quickest, and in many cases the most inexpensive method. The water supplied for domestic purposes,

which has possibly been raised to some height by steam or horse power, gives at once a motive force at the cheapest rate ; while, as channels must necessarily be made for the conveyance away of the waste and dirty water, which has been used for domestic purposes, they can be used with a little alteration for excreta also. It would be a waste of economy to allow this water to pass off without applying the force which has been accumulated in it for another purpose.

But if this is obvious, it is no less so that certain conditions of success must be present, without which this plan, so good in principle, may utterly fail. These conditions are, that there shall be a good supply of water, good sewers, ventilation, a proper outfall, and means of disposing of the sewer water. If these conditions cannot be united, we ought not to disguise the fact that sewers, improperly arranged, may give rise to no inconsiderable dangers. They are underground tubes, connecting houses and allowing possibly, not merely accumulation of excreta, but a ready transference of gases and organic molecules from house to house, and occasionally also causing, by bursting, contamination of the ground, and poisoning of the water supply. And all these dangers are the greater from being concealed. It is probably correct, as has been pointed out, that in deep-laid sewers the pressure inward of the water of the surrounding soil is so great as frequently to cause an inflow *into* the sewer, and so prevent the exit of the contents ; but in other cases, the damage to the sewer may be too great to be neutralized in this way, and in the instance of superficially laid and choked-up pipes, the pressure outward of the contents must be considerable. The dangers of sewers have now been greatly reduced, by having good material, better construction, good ventilation, sufficient water supply, and means of disposal of the sewage water.

Amount of Water for Sewers intended for Excreta.

Engineers are by no means agreed on the necessary amount. We have already named 25 gallons per head per diem, on the authority of Mr. Brunel, as the amount required to keep common sewers clear, and even with this amount there should be some additional quantity for flushing. But in some cases, a good fall and well-laid sewers may require less, and in other cases, bad gradients or curves or workmanship may require more. It is a question whether rain water should be allowed to pass into sewers ; it washes the sewers thoroughly sometimes, but it also carries *débris* and gravel from the roads, which may clog ; while in other cases storm waters may burst the sewers, or force back the sewage.[1]

Construction of Sewers.

Sewers are differently constructed according to the purposes they are to serve, *i.e.*, whether simply to carry off house and trade water, or the solid excreta in addition, or one or both, with the rainfall.

In following out the subject, it will be convenient to trace the sewers from the houses to the outfall.

[1] Storm overflows require to be provided ; for a description of them see Bailey Denton, op. cit., sections lxii. and lxxxv.

House Pipes and Drains.

It will be convenient to call the conduits inside the house, which run from sinks and closets, "house pipes," and to give the term "drain pipes" to the conduits which receive the house pipes, and carry the house water into tanks or main sewers. The house pipes may be divided into sink and water-closet or soil pipes; they are made of metal (lead, iron, or zinc, or two of these) or of earthenware. The drain pipes are usually made of well-burnt, hard, smooth, glazed earthenware.[1] All bricks, porous earthenware, or substances of the kind, should be considered inadmissible for drain pipes. Iron pipes are not much used in this country, but are common and in some places compulsory in America, when pipes have to be carried under houses. When made of heavy cast-iron, jointed and well caulked with lead or Spence's metal, they are the best in many circumstances. Inside they may be enamelled, or coated with Dr. Angus Smith's composition, or treated by Barff's process. The pipes and drains vary in size from 4 to 16 inches diameter,[2] but the usual size of stoneware pipes is 4 to 9 inches; they are round or oval in shape.[3]

Connection of House Pipes with the Drains.—It is customary to commence the drains at the basement of the house, and the sink and closet pipes pass down inside the house and join on, a water-trap being placed at the junction.[4] As the aspiratory power of the warm house is then constantly tending to draw air through the water-trap, and as the trap is liable to get out of order, it is most desirable to alter this plan. The drains should end outside the house, and as far as possible every house pipe should pass outside and not inside or between walls to meet the drain. The object of this is that any imperfection in the pipe should not allow the pipe air to pass into the houses. At the junction of the house pipe and drain, there should not only be a good water-trap, but also complete ventilation and connection with the outside air at the point of junction. The

[1] Mr. Baldwin Latham cautions us to see that the *socket* of the drain pipe is made with and is a component part of the pipe, and not merely joined on.

[2] Pipes are made up to 36 inches, usually round up to 16 or 18 inches, and oval above that. Engineers are now desirous of restricting the term "drain" to a pipe that merely draws off moisture from land, using the term "sewer" for a pipe carrying sewage or liquid refuse of any kind. This distinction, however, has not been made in the Public Health Act of 1875, in which "drain" is used for the pipe that receives the "house pipes," and "sewer" for the main pipe of a system. (See Bailey Denton's Sanitary Engineering, p. 16.)

[3] See Mr. William Eassie's Healthy Houses (2d edition) for much information on this and kindred subjects. Some of the drawings given here have been copied from Mr. Eassie's work, by his permission; reference may also be made to Sanitary Arrangements for Dwellings, by the same author.

[4] Builders are always anxious to conceal tubes, and thus carry them inside the walls, or in the case of hollow walls, between the two. The consequence is that any escape of air must be into the house. The leakage of a closet pipe carried down in a hollow wall often constantly contaminates the air of the house. It would be infinitely better to run the pipes at once through the wall to the outside. Few persons have any idea of the carelessness of plumbers' work—of the bad junctions, and of the rapidity with which pipes get out of order and decay. When a leaden pipe carrying water is led into a water-closet discharge pipe, it is frequently simply puttied in, and very soon the dried putty breaks away, and there is a complete leakage of gas into the house. Even if well-joined, the lead pipe will, it is said, contract and expand, and thus openings are at last formed. Dr. Fergus, of Glasgow, and Dr. N. Carmichael, have directed particular attention to this, in the case of lead closet pipes, which become easily perforated, and which have only a limited duration of wear.

rule, in fact, should be, that the union of any house pipe whatever with the outside drain should be broken both by water and by ventilation. In addition, it should be a strict rule, that no drain pipe of any kind should pass under a house; if there must be a pipe passing from front to back, or the reverse, it is much better to take it above the basement floor than underneath, and to have it exposed throughout its course. In such a case it ought to be of cast-iron, as already mentioned. It is hardly possible to insist too much on the importance of this rule of disconnection between house pipes and outside drains. Late events have shown what a risk the richer classes in this country now run, who not only bring the sewers into the houses, but multiply water-closets, and often put them close to bedrooms. The simple plan of disconnection, if properly done, would insure

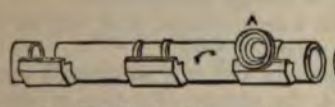


FIG. 76.—Jennings' Access-pipe.

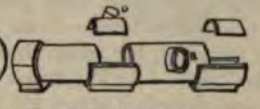


FIG. 77.—Stiff's Access-pipe and Junction.

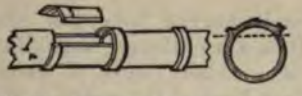


FIG. 78.—Doulton & Watt's Access-pipe.

them against the otherwise certain danger of sewer air entering the house. Houses which have for years been a nuisance from persistent smells have been purified and become healthy by this means.

Cleansing of Pipes and Drains.—Pipes are cleaned by flexible bamboo or jointed rods with screws and rollers to loosen sediment. The safest plan of cleaning drains is from man-holes, the drains being laid in straight lines from man-hole to man-hole. By this means obstructions are easily detected and removed. The use of movable caps runs the risk of leakage, it being difficult to make the drain water-tight again after removing the cap, but with care such caps (see Figs. 75 to 77) are useful with small pipes, where man-holes cannot be employed. Drain pipes should also be cleared out by regular flushing, carried out not less often than once a month. This is best done by means of an automatic apparatus such as Field's flush tank (Fig. 79). By regulating the flow of water, it may be made to empty itself as often as necessary.



FIG. 79.—Field's Flush Tank.

Laying of Drains.—They should be laid very carefully on concrete in all soils. Sometimes, in very loose soils, even piling for the depth of a foot must be used besides the concrete. When pipes are not laid on a good foundation, leakage is sure to occur sooner or later, and the final expense is far more than the first outlay would have been. The greatest care must be taken in laying and joining the pipes, and in testing them afterward to make sure they are water-tight. In a wet soil, a good plan is to have a firm basis, or *invert block*, which

is itself perforated to carry off subsoil water, and to put the drain over this, as in the plan of Messrs. Brooks & Son, of Huddersfield (see Fig. 92).

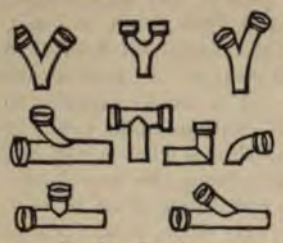


Fig. 80.—Junctions.

The "junction" of pipes is accomplished by special pipes, known by the names of single and double squares, curved or oblique junctions, according to the angle at which one pipe runs into the other. The square junctions are undesirable, as blockage will always occur, and the oblique junctions should be insisted upon. When one pipe opens into another, a taper pipe is often used; the calibre being contracted before it enters the receiving pipe. All jointing must be in good cement, unless special patent joints (such as Stanford's) are used. Clay jointing is wholly inadmissible.

Fall of Drain Pipes.—1 in 30 for 4-inch drains, and one in 40 for 6-inch; or roughly, for small drains 1 inch per yard.

House Traps.—As the traps are usually the only safeguard against the warm house drawing sewer air into it, the utmost attention is necessary to insure their efficiency. There is almost an infinite diversity, but they can be conveniently divided into the *siphon*, the *midfeather*, the *flap-trap*, and the *ball-trap*.

The *siphon* is a deeply curved tube, the whole of the curve being always full of water. It is a useful trap, and efficient if the curve is deep enough, so that there is a certain depth of water (not less than ¾ inch) standing above the highest level of the water in the curve, and if the water is never sucked out of it, and if the pipe is not too small, so that the water is carried away, when it runs full, by the siphon action of the pipe beyond. If two siphons succeed each other in the same pipe, without an air opening between, the one will suck the other empty.

The *midfeather* is in principle a siphon; it is merely a round or square box, with the entry at one side at the top, and the discharge pipe at a corresponding height on the opposite side, and between them a partition reaching below the lower margin of both pipes. Water, of course, stands in the box or receptacle to the height of the discharge, and therefore the partition is always to some extent under water. The extent should not be less than ¾ of an inch. Heavy substances may subside and collect in the box, from which they can be removed from time to time; but as ordinarily made, it is not a good kind of trap, as it favors the collection of deposit, and is not self-cleaning. The common ball-trap, with its modifications, is a variety of the midfeather-trap, but it is so inefficient that it ought to be given up. The best kind of sink trap is the simple siphon, with a screw cap by which to clean it (Fig. 81).



Fig. 81.—Siphon Sink Trap, with movable screw for cleaning.

The *flap* is used only for some drains, and is merely a hinged valve which allows water to pass in one direction, but which is so hung as to close afterward by its own weight. It is intended to prevent the reflux of water into the secondary drains, and is supposed to prevent the passage of sewer gas. But it is probably a very imperfect block.

The *ball-trap* is used in some special cases only; a ball is lifted up as the water rises, until it impinges on and closes an orifice. It is not a very desirable kind.

However various may be the form and details of the water-trap, they can be referred to one or other of these patterns.

Efficiency of Traps.—Water should stand in a trap at least ¾ of an inch above openings, and it should pass through sufficiently often and with sufficient force to clear it. An essential condition of the efficiency of all traps is that they should be self-cleansing. Many traps are so constructed that no amount of velocity of water can clear them. Such traps are the common mason's or dip-trap (Fig. 82), and the notori-



FIG. 82.—Common Mason's or Dip-trap. Bad form of Trap.



FIG. 83.—D Trap. Bad form of Trap.

ous D trap (Fig. 83), both of which are simply cess-pools, and could never be cleaned without being opened up. Such traps ought to be unhesitatingly condemned. Traps are often ineffective,—1st, From bad laying, which is a very common fault. 2d, From the water getting thoroughly impregnated with sewer effluvia, so that there is escape of effluvia from the water on the house side. 3d, From the water passing too seldom along the pipe, so that the trap is either dry or clogged. 4th, From the pipe being too small (2 or 3 inches only), and "running full," which will sometimes suck the water out of the trap; it usually occurs in this way, as frequently seen in sink traps: the pipe beyond the trap has perhaps a very great and sudden fall, and when it is full of water it acts like a siphon, and sucks all the water out of the trap; to avoid this, the pipe should be large enough to prevent its running full, or the trap should be of larger calibre than the rest of the pipe. This, however, will not always prevent it, as even 6-inch pipes have sometimes sucked a siphon dry. The question has lately been very carefully investigated in America, by Messrs. Philbrick and Bowditch,[1] whose report has shown the danger of unsiphoning which small pipes are exposed to. The remedy appears to be to introduce an air-vent at the crown of the trap (see Fig. 84), and not to have too small a pipe, especially when several pipes unite in one general waste. The experiments also showed how unsiphoning might take place from the pressure of descending water from upper floors, so that air might be forcibly driven

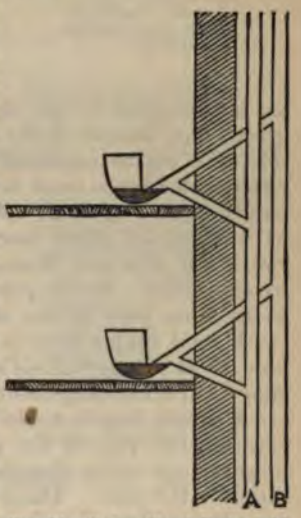


FIG. 84.—Siphon Closet Basins with ventilating pipes. A, Soil pipe passing up above the eaves, with open top. B, Subsidiary Ventilating Pipe (also passing up above eaves, with open top) to prevent sucking of the siphon.

[1] The Sanitary Engineer, vol. vi., p. 264, 1882 (New York). The Siphonage and Ventilation of Traps, Report to the National Board of Health, by E. W. Bowditch and E. S. Philbrick, C.E.

into the house when upper closets or sinks were used. 5th, Traps may perhaps be inefficient from the pressure of the sewer air, combined with the aspirating force of the house displacing the water, and allowing the air uninterrupted communication between the sewer and the house. The extent of the last danger cannot be precisely stated. From a long series of observations on the pressure of the air in the London sewers, Dr. Burdon-Sanderson ascertained that in the main sewers, at any rate, the pressure of the sewer air, though greater than that of the atmosphere, could never displace the water in a good trap. In a long house drain which got clogged, and in which much development of gaseous effluvia occurred, there might possibly be for a time a much greater pressure, but whether it would be enough to force the water back, with or without the house suction, has not been yet experimentally determined. Dr. Neill Carmichael has shown that water siphon traps act efficiently so long as they



FIG. 85.—Pipes opening above Grating and Trap.

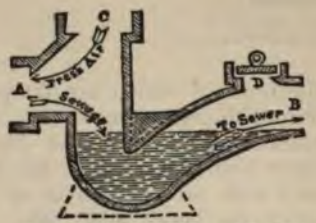


FIG. 86.—Disconnecting and Ventilating Drain Trap, No. 2, Buchan's Patent.



FIG. 87.—Simple Gulley Trap.

are not emptied by any siphon action beyond. But the reasons already given show that we ought not to place dependence solely on traps,[1] though they are useful adjuncts. In arranging the house pipes, the sink and waste-water pipes must not be carried into the closet soil pipes, but must empty in the open air over a grating.[2] See Fig. 85. In the case of soil or water-closet pipes there must be also a complete air-disconnection between the pipe and drain by means of one of the contrivances now used by engineers. At the point where this disconnection is made, there ought to be some easy means of getting at it for inspection.

A good simple form is Buchan's trap (Fig. 86). A good form of manhole is Mr. Rogers Field's (see Figs. 88 to 90).[3] Professor Reynolds[4] has suggested an arrangement which seems fairly good and simple.

A simple trap is made by inserting a pipe in the centre of a siphon, and carrying this pipe to the surface, or higher if considered desirable. It is, however, apt to be clogged with grease, fæces, and other light matter rising into the pipe. There are various similar arrangements. The "Somerset Patent Trap," designed by Mr. Honeyman, and much used at Glasgow,

[1] "Honestly speaking, traps are dangerous articles to deal with; they should be treated merely as auxiliaries to a good drainage system."—EASSIE.

[2] For the sake of appearance in some cases, it may be necessary to carry the pipe immediately *under* the grating, but care must be taken that nothing occurs to obstruct the free communication with the open air through the grating.

[3] From Mr. Field's By-Laws for Uppingham, with later improvements. I am indebted to Mr. Field for several valuable suggestions.—[F. de C.]

[4] Sewer Gas, by Osborne Reynolds, M.A., Professor of Engineering at Owens College, Manchester, 2d edition, 1872.

DISCONNECTING MAN-HOLE.

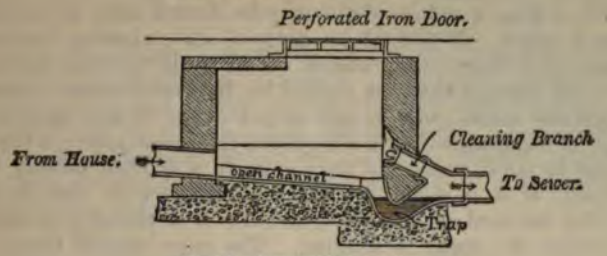


FIG. 88.—Longitudinal Section.

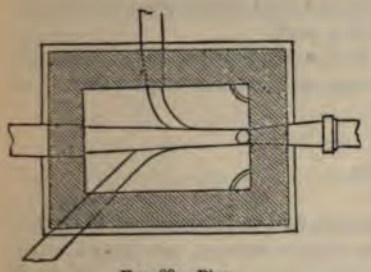


FIG. 89.—Plan.

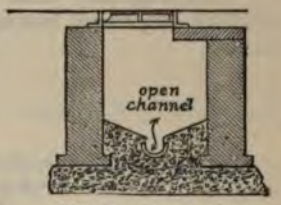


FIG. 90.—Cross Section.

is a midfeather-trap with an air-shaft on each side the partition; on one side the shaft ventilates the pipe leading to the sewer, on the other allows fresh air to pass into the house pipe. This second shaft also allows the trap to be cleaned.

Rain-water pipes are sometimes used to ventilate drains, but independent of their small size, which often leads to blockage, they are often full of rain, and cannot act at the time when ventilation is most required. They are also apt to deliver sewer gas into garret windows. The plan is objectionable, and ought to be abandoned.

A good form of disconnecting trap for sink and slop waters is Dean's, which has a movable bucket for removing deposit (Fig. 91).

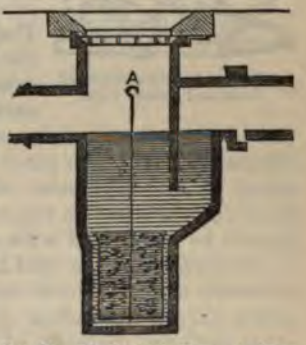


FIG. 91.—Dean's Gully Trap. A, Handle of movable bucket.

In yards, gully traps of different kinds are used, the action of which will be at once understood from the drawing (Fig. 87).

Examination of House Pipes and Traps.

Pipes and traps are generally so covered in that they cannot be inspected; but this is a bad arrangement. If possible, all cover and skirting boards concealing them should be removed, and the pipe and trap underground laid bare, and every joint and bend looked to. But supposing this cannot be done, and that we must examine as well as we can in the dark, so to speak, the following is the best course:—Let water run down the pipe, and see if there is any smell; if so, the pipe is full of foul air and

wants ventilation, or the trap is bad. If a lighted candle, or a bit of smouldering brown paper, is held over the entrance of the pipe or the grating over a trap, a reflux of air may be found with or without water being poured down. It should be noticed, also, whether the water runs away at once, or if there is any check. This is all that can be done inside the house; but though the pipe cannot be disturbed inside, it may be possible to open the earth outside, and to get down to and open a drain; in that case, pour water mixed with lime down the house pipe; if the whitened water is long in appearance, and then runs in a dribble merely, the drains want flushing; if it is much colored and mixed with dirt, it shows the pipes and trap are foul, or there is a sinking or depression in some part of the drain where the water is lodging. The pipe should then be flushed by pouring down a pailful of lime and water till the lime-water flows off nearly clear. The drain should also be blocked, and water poured into the house pipe to see if it be water-tight in every part.

Yard-traps are often very foul, and if the trap-water be stirred, gas bubbles out, which is a sign of great foulness, or that the traps are seldom used.

Main Sewers.

The outside house drain ends in a channel which is common to several drains, and which is of larger size. These larger sewers are made either of round glazed earthenware pipes from 15 to 24 inches diameter, or of well-burnt impervious brick moulded in proper curved shape and set in Portland cement, or stoneware bricks are partly used. The shape now almost universally given, except in the largest outfall part, is that of an egg with the small end downward. Engineers take the greatest care with these brick sewers; they are most solidly put together in all parts, and are bedded on a firm unyielding bed. Much discussion has taken place as to their size, but the question is so complicated by the admission of rain water, that it is difficult to lay down any fixed rule, at least as regards the main pipes. All other sewers, however, should be small, and with such a fall as to be self-cleansing.



FIG. 92.—Brooks's combined Drain and Subsoil Pipe.

Sewers should be laid in as straight lines as possible, with a regular fall; tributary sewers should not enter at right angles, but obliquely; and if the sewer curves, the radius of the curve should not be less than 10 times the cross sectional diameter of the sewer. Sometimes there is an arrangement for subsoil drainage under a pipe drain, as in the plan proposed by Mr. Brooks.

The fall for street drains is usually from 1 in 244 to 1 in 784, according to the size of the drain. The flow through a sewer should in no case be less than 2 feet per second, and 3 is better. As in the house drain, the fall should be equable without sudden changes of level.[1]

[1] In some cases a fall is almost impossible to obtain, as, for instance, at Southport, in Lancashire, where the ground is nearly a dead level. The fall there is about 1 in 5,000, and never exceeds 1 in 3,000. In such a case the drain would have to be cleaned either by locks or valves (flushing-gates) to retain a portion of the contents for a time, and then set them free suddenly in order to flush the next section, or by special arrangements, such as Field's flush-tank.

Access to Sewers.

It is of importance that to all sewers capable of being entered by a man, there should be an easy mode of access. Man-holes opening above, or, what is better, at the side, should be provided at such frequent intervals, that the sewers can be entered easily and inspected at all points. The man-holes are sometimes provided with an iron shutter to prevent the sewer air passing into the street, or by the side of the man-hole there may be a ventilating chamber.[1]

Calculation of Discharge from Sewers.[2]

Several formulæ have been given, of which the following is the most simple :—

$$V = 55 \times (\sqrt{D} \times 2F).$$

V = velocity in feet per minute.
D = hydraulic mean depth.
F = fall in feet per mile.

Then, if A = section area of current of fluid, VA = discharge in cubic feet per minute.

To use this formula, the hydraulic mean depth when the sewage is flowing, and the amount of fall in feet per mile, must be first ascertained. The hydraulic mean depth is ¼th the diameter in circular pipes ; in pipes other than circular, it is the section area of current of fluid divided by the wetted perimeter. The wetted perimeter is that part of the circumference

[1] Mr. Baldwin Latham joins the sewers in man-holes, so that if one is blocked another may be used ; the outlet being at the lower level.

[2] The following table, taken from Mr. Wicksteed, will be found useful :—

Sewers.

Diameter.	Velocity in feet per minute.	Gradient required.	Diameter.	Velocity in feet per minute.	Gradient required.
4 inches	240	1 in 36	18 inches	180	1 in 294
6 "	220	1 " 65	21 "	180	1 " 343
8 "	220	1 " 87	24 "	180	1 " 392
9 "	220	1 " 98	30 "	180	1 " 490
10 "	210	1 " 119	36 "	180	1 " 588
15 "	180	1 " 244	48 "	180	1 " 784

Mr. Latham (Lectures on Sanitary Engineering, delivered to the Royal Engineers at Chatham) gives a table, of which the following is an extract :—

Diameter in inches.	Rate of inclination for velocity per second.				
	2 feet.	3 feet.	4 feet.	5 feet.	6 feet.
4	1.194	1.92	1.53	1.34	1.24
6	292	137	80	51	36
8	389	183	106	69	48
9	437	206	119	77	54
10	486	229	133	86	60
12	583	275	159	103	72

In this table the velocity in feet multiplied by the inclination equals the length of the sewer to which the calculation applies. For example, if the velocity is 6 feet per second in a pipe whose diameter is 4 inches, then $6 \times 24 = 144$ feet is the length of the sewer.

of the pipe wetted by the fluid. The fall in feet per mile is easily obtained, as the fall in 50 or 100 or 200 feet can be measured, and the fall per mile calculated (5,280 feet = 1 mile).

Movement of Air in the Sewers and Ventilation.

It seems certain that no brick sewer can be made air-tight; for on account of the numerous openings into houses, or from leakage through brickwork, or exit through gratings, man-holes, and ventilating shafts, the air of the tubes is in constant connection with the external air. There is generally, it is believed, a current of air with the stream of water if it be rapid. The tension of air in main sewers is seldom very different from that of the atmosphere, or if there be much difference equilibrium is quickly restored. In twenty-three observations on the air of a Liverpool sewer, it was found by Drs. Parkes and Burdon-Sanderson,[1] that in fifteen cases the tension was less in the sewer than in the atmosphere outside (*i.e.*, the outside air had a tendency to pass in), and in eight cases the reverse; but on the average of the whole there was a slight indraught into the sewer. In the London sewers, on the other hand, Sanderson noticed an excess of pressure in the sewers.

If at any time there is a very rapid flow of water into a sewer, as in heavy rains, the air in the sewer must be displaced with great force, and possibly may force weak traps; but the pressure of air in the sewers is not appreciably affected by the rise of the tide in the case of seaboard towns.[2] The tide rises slowly, and the air is displaced so equably and gradually through the numerous apertures, that no movement can be detected. It is not possible, therefore, that it can force water-traps in good order, when there are sufficient ventilating apertures.

On the contrary, the blowing off of steam, or the discharge of air from an air-pump (as in some trade operations), greatly heightens the pressure, and might drive air into houses. So also the wind blowing on the mouth of an open sewer must force the air back with great force.

It is, therefore, important to protect the outfall mouth of the sewer against wind by means of a flap, and to prohibit steam or air being forced into sewers.

To how great an extent it is the openings into houses which thus reduce the tension of the air in main sewers is difficult to say, but there can be little doubt that a large effect is produced by houses which thus act as ventilating shafts.

When a sewer ends in a *cul-de-sac* at a high level, sewer gas will rise and press with some force; at least in one or two cases, the opening of such a *cul-de-sac* has been followed by so strong a rush of air as to show that there had been considerable tension. It is also highly probable, from the way in which houses standing at the more elevated parts of sewers, and communicating with them, are annoyed by the constant entrance of sewer air, while houses lower down escape, that some of the gases may rise to the higher levels.

That no sewer is air-tight is certain, but the openings through which the air escapes are often those we should least desire. It is therefore absolutely necessary to provide means of exit of foul and entrance of fresh air, and not to rely on accidental openings. The air of the sewer should

[1] Report on the Sanitary Condition of Liverpool, 1870, p. 27.

[2] Vide same Report, p. 21, for the case of Liverpool. Dr. Corfield's observation at Scarborough was confirmatory.

be placed in the most constant connection with the external air, by making openings at every point where they can be put with safety. In London there are numerous gratings which open directly into the streets, and this plan, simple and apparently rude as it is, can be adopted with advantage whenever the streets are not too narrow. But in narrow streets the sewer gratings often become so offensive that the inhabitants stop them up. In such cases there must be ventilating shafts of as large a diameter as can be afforded, and running up sufficiently high to safely discharge the sewer air.[1] In some of these cases it may be possible to connect the sewers with factory chimneys.[2] The sewer should never be connected with the chimneys of dwelling-houses.

In making openings in sewers it seems useless to follow any regular plan. The movement of the sewer air is too irregular to allow us to suppose it can ever be got to move in a single direction, though probably the most usual course of the air current is with the stream of water, if this be rapid. The openings should be placed wherever it can conveniently be done without creating a nuisance. Some of these openings will be inlets, others outlets, but in any case dilution of the sewage effluvia is sure to be obtained. Mr. Rawlinson considers that every main sewer should have one ventilator every 100 yards, or 18 to a mile, and this should be a large effective opening.[3]

But there may be cases when special appliances must be used. For example, in what are called "sewers of deposit," as when the outflow of the sewer water is checked for several hours daily by the tide or other causes, it may be necessary to provide special shafts, and the indication for this will be the evidence of constant escape of sewer air at particular points.

The use of *charcoal trays* has not answered the expectations that were formed of them.

Inspection of Sewers.

The inspection of sewers is in many towns a matter of great difficulty, on account of the means of access being insufficient, and also because the length of the sewers is so great. Still inspection is a necessity, especially in the old flat sewers, and should be systematically carried out, and a record kept of the depth of water, the amount of deposit, and of sewer slime on the side or roof.

Choking of and Deposits in Sewers—Causes.—Original bad construction; too little fall; sharp curves; sinking of floor; want of water; check of flow by tides, so that the heavy parts subside.

Well-made sewers with a good supply of water are sometimes self-cleansing, and quite free from deposit, but this is, unfortunately, not always the case.

Even in so-called self-cleansing sewers, it has been noticed by Mr. Rawlinson that the changing level of the water in the sewers leaves a deposit on the sides, which, being alternately wet and dry, soon putrefies.

[1] In Liverpool there were small shafts with Archimedean screws at the top. From the observations of Sanderson and Parkes, it appears that these screws did act, but not to such an extent as to warrant the expense.

[2] It seems inadvisable to erect chimneys and use fires with an idea of ventilating the sewers on a general plan, the air would simply be drawn with great force through the nearest openings. But local ventilation by a factory chimney, when gratings cannot be used, is a different thing.

[3] Others have recommended 1 in 50 yards.

In foul sewers a quantity of slimy matter collects on the crown of the sewers; it is sometimes 2 to 4 inches in thickness, and is highly offensive. When obtained from a Liverpool sewer by Drs. Parkes and Burdon-Sanderson, it was found alkaline from ammonia and containing nitrates.[1] On microscopic examination, this Liverpool sewer slime contained an immense amount of fungoid growth and *Bacteria*, as well as some *Confervæ*. There were also *Acari* and remains of other animals and ova.

When deposits occur, they are either removed by the sewer-men, or they are carried away by flushing of water.

Flushing of Sewers.—This is sometimes done by simply carrying a hose from the nearest hydrant into the sewer, or reservoirs are provided at certain points which are suddenly emptied. The sewer water itself is also used for flushing, being dammed up at one point by a flushing gate, and when a sufficient quantity has collected the gate is opened.[2] An automatic system is however preferable, such as is carried out by Field's annular siphon, before mentioned.

Almost all engineers attach great importance to regular flushing, and almost the only advantage of allowing the rain to enter the sewers is the scouring effect of a heavy rainfall which is thus obtained. This, however, is so irregular that it is but a doubtful benefit.

Disposal of the Sewer Water.

The great engineering skill now available in all civilized countries can insure in the case of any new works that the construction of sewers shall be perfect. If an engineer can obtain good materials, good workmen, and a proper supply of water, there is no doubt that sewers can be so solidly constructed and so well ventilated that the danger of deposits in the sewers, or of sewer air entering and carrying disease into houses, is removed.

But the difficulty of the plan of removing excreta by water really commences at the outfall. How is the sewer water to be disposed of?

This difficulty is felt in the case of the foul water flowing from houses and factories without admixture of excreta almost as much as in sewer water with excreta. The exclusion of excreta from sewers, as far as it can be done, would not solve the problem—would, indeed, hardly lessen its difficulty. In seaboard towns the water may flow into the sea, but in inland towns it cannot be discharged into rivers, being now prohibited by law. Independent of the contamination of the drinking water, the sewer water often kills fish, creates a nuisance which is actionable, and in some cases silts up the bed of the stream. It requires in some way to be purified before discharge. At the present moment the disposal of the sewer water is the sanitary problem of the day, and it is impossible to be certain which of the many plans may be finally adopted. It will be convenient to briefly describe these plans.

[1] Report on the Sanitary State of Liverpool, by Drs. Parkes and Burdon-Sanderson, 1871. The amount of free ammonia was .025 parts per cent.; the albuminoid ammonia was .00462, and the nitric acid .2035 parts per cent. Photographs are given of the microscopic appearances of the slime in this report.

[2] Baldwin Latham points out that there is a point of flow in all sewers when they discharge more than when running full. A good flushing power may be obtained at considerably less than the full discharge. Tables are given in his Sanitary Engineering.

1. STORAGE IN TANK, WITH OVERFLOW.

The sewer water runs into a cemented tank with an overflow-pipe, which sometimes leads into a second tank similarly arranged; the solids subside, and are removed from time to time; the liquid is allowed to run away. Instead of letting the liquid run into a ditch or stream, it has been suggested to take it in drain pipes, ½ to 1 foot under ground, and so let it escape in this way into the subsoil, where it will be readily absorbed by the roots of grasses. The fat, grease, and coarser solids may be intercepted by a strainer, and daily removed and mixed with earth. The liquid portions may be discharged periodically by means of the automatic flush-tank.[1] In a light soil this could no doubt be readily done; and, if the drain pipes are well laid, a considerable extent of grass land could be supplied by this subterranean irrigation. The tank plan is, however, only adapted for a small scale, such as a single house or small village, and there should be ventilation between the tank and the house in all cases. This plan is applicable to the disposal of slop-waters in villages, even when the excreta are dealt with by dry methods.

2. DISCHARGE AT ONCE INTO RUNNING WATER.

All new works of this description are now prohibited, and the plan will probably ultimately cease in this country.[2]

3. DISCHARGE INTO THE SEA.

The outlet pipe must be carried to low water, and, if possible, should be always under water. A tide flap opening outward is usually provided. If not under water constantly, special care must be taken to prevent the wind blowing up the sewers. The tide will fill the outfall sewers (which are generally made large) to the level of high water, and to that extent will check the discharge, and in the sewers filled with the mixed sea water and sewage there will be deposit. To remove this special attention is necessary.

[1] See Mr. Rogers Field's evidence, Annual Conference on the Progress of Public Health at the Society of Arts, 1880.

[2] When the sewer water passes into a river it undergoes considerable purification by subsidence, by the influence of water plants, and in a lesser degree by oxidation. Although some oxidation of nitrogenous organic matters into nitrous and nitric acids and ammonia must take place, it appears from Franklin's experiments,[3] that in the River Irwell, which receives the sewage of Manchester, after a run of 11 miles, and falling over six weirs, there is no formation of nitrites and nitrates, and there is even an increase in the organic nitrogen (?), though the suspended matters are less (from 2.8 to 1.44 parts per 10,000) than at first. Average London sewage diluted with 9 parts of water and siphoned from one vessel into another so as to represent a flow of 96 and 192 miles, gave a percentage reduction in the organic nitrogen of 28.4 and 33.3 respectively. The oxidation of sewage appears, then, from these experiments, to take place slowly. Dr. Letheby considers, however, that oxidation takes place more rapidly, and that if sewage is mixed with 20 times its bulk of water, and flows for 9 miles, it will be perfectly oxidized.[4] Of course, it is clear that ova, and solid parts of the body, like epithelium, might be totally unchanged for long periods,[5] and we may conclude that oxidation of sewage in running water cannot be depended on for perfect safety.

[3] Reports of the Commissioners appointed to inquire into the Pollution of Rivers, 1870, vols. i., ii., and iii.

[4] Reports of East London Water Bill Committee (1867), p. 430, questions 732–4.

[5] As formerly mentioned, Dr. Parkes found unchanged epithelium in unfiltered Thames water after a transit in a barrel of 180 miles, and after keeping for five months. It was transparent and worn, but quite recognizable.

If the sewage cannot be got well out to sea, and if it issues in narrow channels, it may cause a nuisance, and may require to be purified before discharge. In the Rivers Pollutions Act (1876) power is given to prohibit discharge into the sea or tidal waters under certain circumstances.[1]

4. PRECIPITATION.

Another plan is not to pour the whole sewage into rivers, but to precipitate the solid part, or the greater portion of it, and then to allow the liquid to pass into the stream or over the land.

This is sometimes done by simple subsidence, the sewage being received into settling reservoirs or trenches, with strainers to arrest the flow to some extent. When the solid matter has collected to a certain amount, the sewage is turned into another reservoir, and the thick part, being mixed with coal refuse or street sweepings, is sold as manure.

The thin water which runs off must be almost as dangerous as the sewage itself when poured into streams, and consequently the prohibition to discharge sewer water extends to it also.

In order to produce greater purification, the sewage in the subsiding tanks is now usually mixed with some chemical agents which may precipitate the suspended matters.

Numerous substances have been employed as precipitants.[2]

Lime Salts.—Quicklime (proportion 8 to 12 grains per gallon), or 1 lb of lime for 600 gallons of sewage (nearly); chloride of lime, which is added to quicklime in the proportion of about $\frac{1}{40}$th part of chloride to 1 of lime; calcic phosphate dissolved in sulphuric acid, or a mixture of mono- and di-calcic phosphate with a little lime (Whitthread's patent),[3] are said to be good precipitants. Chloride of calcium has also been recommended.

Aluminous Substances.—Aluminous earth mixed with sulphuric acid (Bird's process); impure sulphate of aluminum (Anderson's and Lenk's processes); refuse of alum works, either alone or mixed with lime or charcoal; clay mixed with lime (Scott's cement process); natural phosphate of aluminum dissolved by sulphuric acid and mixed with lime. In all these cases the amount of the substance added is from 50 to 80 grains per gallon of sewer water.

Magnesian Salts mixed with lime in the form of superphosphates (Blyth); impure chloride of magnesium.

Carbon in the shape of vegetable charcoal; peat; sea-weed charcoal; carbonized tan; lignite; Boghead coke.

[1] The word "stream" (into which sewage is not to be passed) is defined by section 20 of the Act, thus:—"Stream includes the sea to such extent and tidal waters to such point, as may, after local inquiry and on sanitary grounds, be determined by the Local Government Board, by order published in the London Gazette. Save, as aforesaid, it includes rivers, streams, canals, lakes, watercourses, other than watercourses, at the passing of this Act, mainly used as sewers, and emptying directly into the sea or tidal waters, which have not been determined to be streams within the meaning of this Act by such order as aforesaid."

[2] An interesting account of the precipitating process is given in a book called The Sewage Question, the author of which has had the advantage of Dr. Letheby's notes and analyses. A list of no less than 57 processes or proposals is given at page 38, from which it appears that the first precipitant was proposed by Deboissieu so long ago as 1762, and was a mixture of acetate of lead and proto-sulphate of iron.

[3] This patent was found to give good results in removing suspended matters and organic nitrogen, and the Committee of the British Association considered the process deserved "further investigation." It appears, however, to have come at present to a standstill.

Iron in the shape of sulphate; perchloride (Ellerman's and Dale's liquid); the sulphate is sometimes mixed with lime and coal dust.

Manganese.—Condy's fluid.

Zinc sulphate and chloride.

The deposit obtained from any of these processes is collected and dried. It is usually dried on a hot floor, a stream of hot air being allowed also to pass over it. There is some little difficulty in drying it, but this is now being overcome. Of these various precipitants the best appear to be the aluminous preparations; the crude sulphate of aluminum prepared by Dr. Anderson, of Coventry; the solution patented by Mr. Lenk; the A B C process of Mr. Sillar, which consists of alum, blood, charcoal, and clay;[1] and Mr. Forbes's sulphuric acid solution of natural phosphate of aluminum. All produce rapid subsidence of the suspended matters, and clarify the liquid to a very great extent. The sulphuric acid also tends to prevent decomposition of the deposit. In using these substances the sewage water is received into a tank or well, and there, or on its way thither, receives the precipitating agent, which is generally mixed by means of a screw or turbine. After thorough mixing, the precipitate is allowed to subside, and the superabundant water is run off. The deposit is then dug out and dried. After drying the deposit appears to possess some agricultural value,[2] and to be saleable at a price which, in some cases, leaves a small profit. The profit is never large, and in some instances there has been even a loss. The clear water from all these processes contains ammonia and oxidizable organic matters, as well as phosphoric acid (in most cases) and potash, and it would thus appear that a considerable part of the substances which give fertilizing power to sewage remain in the effluent water.

The caustic lime process, when properly applied, appears also to be a powerful precipitant, but the deposit has no agricultural value.

The metallic precipitants of various kinds (iron, zinc, manganese) are more expensive and less useful. Blyth's magnesian process was unfavorably reported on by Mr. Way.

When the sewer water is cleared by any of these plans, is it fit to be discharged into streams? In the opinion of some authorities, if the precipitate is a good one it may be so, and it appears certain that in many cases it is chemically a tolerably pure water, and it will no longer silt up the bed or cause a nuisance. But it still contains in all cases some organic matter, as well as ammonia, potash, and phosphoric acid.[3] It has, therefore, fertilizing powers certainly, and possibly it has also injurious powers. No proof of this has been given, but also no disproof at present, and when we consider how small the agencies of the specific diseases probably are,

[1] The proportions are stated to be, 6 grains of alum, ½ grain of blood, 20 grains of clay, and 6 grains of charcoal, to 10,000 grains of sewer water. Sometimes a little lime is added.

[2] This never exceeds one-third of the theoretical or chemical value. Thus the product by Anderson's process at Coventry is estimated *theoretically* at 16s. 9½d. per ton; the *practical* value is only 5s. 6d. to 8s. 4d. See Dr. Voelcker's Reports, in the Report of a Committee on Town Sewage (1875), p. lx. et seq.

[3] Many analyses are given in the First and Second Reports of the Rivers Pollution Commissioners, from which it appears that on an average the chemical processes remove 89.8 per cent. of the suspended matters, but only 36.6 per cent. of the organic nitrogen dissolved in the liquid. Mr. Crookes's analyses show that the A B C process, when well carried out, removes all the phosphoric acid. Voelcker's analysis of the effluent water treated by the acid phosphate of aluminum shows that it contains more ammonia than the original sewer water, less organic nitrogen by one-half, and less phosphoric acid; it is pure enough to be discharged into streams.

and how likely it is that they remain suspended, we do not seem to be in a position to expect that the water, after the subsidence of the deposit, will be safe to drink. We must adopt here the plan which is the safest for the community; and the effluent water should therefore be used for irrigation, or be filtered before discharge. The clear fluid is well adapted for market gardens; the plants grown as vegetables for the table are sometimes injured by irrigation with unpurified sewer water, but they thrive with the purified effluent water.

In arranging any processes for precipitation everything must be as simple as possible; there is no margin for expenditure or complicated arrangements.

Sewage Cement.

Instead of using the dried deposit as manure, General Scott has proposed to make cement, and for this purpose adds lime and clay to the sewer water. The deposit contains so much combustible matter that it requires less coal to burn it than would otherwise be the case, and the saving thus effected enables (it is supposed) cement to be sold at a remunerative rate. If this should turn out to be the case, the sewage cement process has the advantage of destroying by fire everything which might be injurious in the deposit, while the effluent water, which contains rather more than two-thirds of the chlorine and three-fourths of the dissolved nitrogen, has some value as an irrigator. At present the pecuniary results of the process cannot be properly determined. General Scott also proposes to use the burnt material as manure to *lime* the land in some cases.

5. FILTRATION THROUGH EARTH, CHARCOAL, ETC.

By filtration through earth is meant the bringing of sewer water upon a comparatively small area of porous soil, which is broken up and comminuted above, and is deeply underdrained, so that the sewer water may pass through the soil and issue by the drains. Mr. Dyke, in explaining the system employed at Merthyr-Tydvil[1] by Mr. Bailey Denton, lays down the following conditions:—There should be—1st, a porous soil; 2d, an effluent drain, not less than 6 feet from the surface; 3d, proper fall of land to allow the sewage to spread over the whole land; and 4th, division of filtering area into four parts, each part to receive sewage for six hours, and to have an interval of eighteen hours. He considers that an acre of land would take 100,000 gallons per day, though this seems a rather large amount. At Merthyr-Tydvil 20 acres of land were divided into beds, which sloped toward the effluent drain by a fall of 1 in 150. The surface was ploughed in ridges, on which vegetables were sown; the sewage (strained) passed from a carrier along the raised margin of each bed into the furrows. The effluent water was stated to be pure enough to be used for drink. Since 1872 these filter-beds, as well as 230 acres of other portions of the land, have been used as ordinary irrigation ground. The effluent water remains bright and pure.[2] Another case of marked success with intermittent filtration is that of Kendal. The best soil for filtration appears to be a loose marl, containing hydrated iron oxide and alumina, but sand and even chalk produce excellent results. But in order that fil-

[1] On the Downward Intermittent Filtration of Sewage at Merthyr-Tydvil, by T. J. Dyke, F.R.C.S. Eng.

[2] Report on Town Sewage.

tration shall be successful it is necessary that the amount of filtering material shall be large ; it must not be less than 1 cubic yard for 8 gallons of sewage in twenty-four hours,[1] and in the case of some soils must be more. If the drains are 6 feet below the surface, then an acre will contain 9,680 cubic yards of filtering material, and at 8 gallons per yard an acre would suffice for 77,440 gallons. Crops may be grown on the land, and indeed it is desirable that they should be.

When the filters are too small, they fail to do much good ; and Letheby has given analyses which prove that small filters may be nearly useless. It appears undesirable to use charcoal filters on this account, and all filtration through charcoal has been a failure. *Spongy iron* has been lately very strongly recommended. *Carferal* has also been suggested.

Filtration may be downward or upward, but the former kind is much more efficacious. Upward filtration may be said to be now abandoned.

Condition of the Effluent Water.—When 5.6 gallons of sewage were filtered in twenty-four hours through a cubic yard of earth, it was found by the Rivers Pollution Commissioners that the organic carbon was reduced from 4.386 parts to .734, and the organic nitrogen from 2.484 parts to .108 parts in 100,000. The whole of the sediment was removed. Nitrates and nitrites, which did not exist before filtration, were found afterward, showing oxidation.

6. IRRIGATION.[2]

By irrigation is meant the passage of sewer water over and through the soil, with the view of bringing it as speedily as possible under the influence of growing plants. For this purpose it is desirable that the sewer water should be brought to the land in as fresh a state as possible. In some cases, as at Carlisle, carbolic acid in small quantities has been added to the sewage in its flow for the purpose of preventing decomposition, and the plan appears to be effectual. The sewer water is usually warmer than the air at all times, and will often cause growth even in winter.

The effect on growing plants, but especially on Italian rye-grass, is very great ; immense crops are obtained, although occasionally the grass is rank and rather watery. For cereals and roots it is also well adapted at certain periods of growth, as well as for market vegetables when the viscid parts are separated. When the sewer water permeates through the soil there occur—1st, a mechanical arrest of suspended matters ; 2d, an oxidation producing nitrification, both of which results depend on the porosity and physical attraction of the soil ; and, 3d, chemical interchanges. The last action is important in agriculture, and has been examined by Bischof, Liebig, Way,[3] Henneberg, Warrington,[4] and others. Hydrated ferric oxide

[1] The Rivers Pollution Commissioners give a smaller amount, viz., 5½ gallons per cubic yard; but some of their experiments seem to show that we must increase the amount. For example, the soil at Beddington was found by them to have a remarkable power of nitrification up to the extent of 7.6 gallons per cubic yard in twenty-four hours. But when this rate was doubled nitrification ceased, and the soil became clogged. The best soil experimented on (Dursley soil), containing 43 of silica and 18 of oxide of iron, purified 9.9 gallons in twenty-four hours per cubic yard. But as few soils would be so good, the limit of 8 gallons is selected in the text.

[2] On the application of sewage to land many works have been published. Dr. Corfield's work on the Treatment and Utilization of Sewage, 2d edition, and the Report of the Committee of the British Association, 1872, give the best summary of the subject up to date of publication. Also the Report of the Committee on Town Sewage, 1876.

[3] Journal of Royal Agricultural Society, vol. xi.

[4] Chemical News, May, 1870. Warrington's paper gives a good résumé of the subject, and many original experiments, and can be consulted for full details.

and alumina absorb phosphoric acid from its salts, and a highly basic compound of the acid and metallic oxide is formed. They act more powerfully than the silicates in this way. The hydrated double silicates absorb bases. Silicates of aluminum and calcium absorb ammonia and potassium from all the salts of those bases, and a new hydrated double silicate is formed, in which calcium is more or less perfectly replaced by potassium or ammonium. Humus also forms insoluble compounds with these bases. Absorption of potash or ammonia is usually attended with separation of lime, which then takes carbonic acid.

The soil must be properly prepared for sewage irrigation; either a gentle slope, or a ridge with a gentle slope on each side of about 30 feet wide,[1] with a conduit at the summit, or flat basins surrounded by ridges, are the usual plans. The sewer water is allowed to trickle down the slope at the rate of about 8 feet per hour, or is let at once into the flat basin. The water passes through the soil, and should be carried off by drains from 5 to 6 feet deep, and thence into the nearest water-course.

The sewer water should reach the ground in as fresh a state as possible; it is usually run through coarse strainers to arrest any large substances which find their way into the sewers, and to keep back the grosser parts which form a scum over the land; it is then received into tanks, whence it is carried to the land by gravitation, or is pumped up. The "carriers" of the sewer water are either simple trenches in the ground, or brick culverts, or concreted channels, and by means of simple dams and gates the water is directed into one or other channel as may be required. Everything is now made as simple and inexpensive as possible—underground channels and jets, hydrants, hose and jets, are too expensive, and overweight the plan with unnecessary outlay.

The amount of land required is, on an average, 1 acre to 100 persons; this is equal to a square of 70 yards to the side, and will take 2,000 gallons in twenty-four hours.

The sewer water is applied intermittently when the plants are growing; but in winter it is sometimes used constantly, so as to store up nourishment in the soil for the plant-growth in the spring.[2]

The amount of sewer water which can be applied will vary with the kind of ground, the amount of rain, and the season of the year. In the year ending 1871, it appears that, on the Lodge farm at Barking, 622,324 tons of sewage were applied to 163 acres (nearly), or about 3,800 tons per acre. In the sixteen months ending December, 1872, the average quantity

[1] This was the arrangement of Mr. Hope's farm at Romford.

[2] See an interesting paper on the "Utilization of the Sewage of Paris," by Sandford Moore, B.A., Assist.-Surgeon, 4th Dragoon Guards (Medical Times and Gazette, June, 1870). In the summer "arrosage" is practised; the land is ploughed in furrows and ridges, and the water is allowed to flow into the furrows, and not allowed to wet the vegetables which are planted on the ridges. In winter "colmatage" is had recourse to; the ridges are levelled and the entire surface is submerged under sewage water. The sewers of Paris receive only a small part of the solid excreta (though most of the urine), but the fluid is highly fertilizing. Precipitation with alum was also formerly had recourse to in Paris, but has now been abandoned.

For detailed information see the Report of the Prefecture of the Seine, Sur l'Assainissement de la Seine. An abstract is given in the Annales des Ponts et Chaussées, and is translated by R. Manning, M.I.C.E. (E. & F. N. Spon), 1876. Similar works are in process at Berlin, and are described in the same paper. At Brussels, the Senne, during its passage through the city, is no longer used as the main sewer, and although the sewage is still poured into it at a lower point, it will ultimately be disposed of by irrigation.

was 3,342 tons per acre annually, On the most porous part of the farm as much as 960 tons have been applied in twelve hours.[1]

Condition of the Effluent Water after Irrigation.

When the sewer water passes over and not through the soil, it is often impure, and even suspended matters of comparatively large size (such as epithelium) have been found in the water of the stream into which it flows. It requires, therefore, that care shall be taken in every sewage farm that the water shall not escape too soon. Dr. Letheby,[2] whose authority on such a question no one can doubt, rated the cleansing power of soil much lower than the Rivers Pollution Commissioners or the Committee of the British Association, and his analyses make it at any rate quite certain that the proper purification of the sewer water demands very careful preparation of the ground in the first instance, and constant care afterward. But the chemical evidence of the good effect of irrigation is too strong to admit a doubt to exist, as may be seen from the table given by the Rivers Pollution Commissioners.[3]

The results are much better than those of any chemical precipitant, although they are not quite so good as the downward filtration plan.

[1] Mr. Morgan's Report, quoted in Food, Air, and Water, December, 1871.

[2] The Sewage Question, 1872, pp. 3–27.

[3] The standard of purity which effluent water should have has not yet been fixed. That proposed by the Rivers Pollution Commissioners, which is based on the method of analysis proposed by Dr. Frankland, and which is not yet universally admitted, was as follows:—

Standard of Rivers Pollution Commissioners. Maximum of Impurity permissible in 100,000 parts by weight of the liquid.

Dry mineral matter in suspension.	Dry organic matter in suspension.	Color.	In Solution.					
			Organic carbon.	Organic nitrogen.	Any metal except Calcium, Magnesium, Potassium, or Sodium.	Arsenic.	Chlorine.	Sulphur as SH_2, or sulphate.
3	1	Shown in a stratum of 1 inch in a white plate.	2	.3	2	.05	1	1

A certain degree of acidity or alkalinity is also ordered not to be surpassed. In the discussions on the Public Health Bill in the House of Commons, this standard, which had been embodied in the Bill, was struck out, and the standard is left to be hereafter determined. (No standard is given in the Rivers Pollution Act of 1876.) The objection to the plan is not merely the doubt about the substances represented by organic carbon or nitrogen, but also because the standard does not take into consideration the volume of water into which the foul water flows. The Thames Conservancy Commissioners adopt a standard for effluent sewage as follows:—

	Must not exceed in 70,000 parts.
Suspended matters	3 parts.
Total solids	70 "
Organic carbon	2 "
Organic nitrogen	0.75 "

Do Sewage Irrigation Farms affect the Public Health or Public Comfort?

That sewage farms, if too near to houses and if not carefully conducted, may give off disagreeable effluvia, is certain; but it is also clear that in some farms this is very trifling, and that when the sewer water gets on the land it soon ceases. It is denied by some persons that more nuisance is excited than by any other mode of using manure. As regards health, it has been alleged that these farms may—1st, give off effluvia which may produce *enteric fever*, or *dysentery*, or some allied affection; or, 2d, aid in the spread of *entozoic* diseases; or, 3d, make ground swampy and *marshy*, and may also poison wells, and thus affect health.

The evidence of Edinburgh, Croydon,[1] Aldershot, Rugby, Worthing, Romford, the Sussex Lunatic Asylum,[2] is very strong against any influence in the production of typhoid by sewage farms' effluvia. On the other hand, Dr. Clouston's record of the outbreak of dysentery in the Cumberland Asylum is counter-evidence of weight, and so is one of the cases noted by Letheby,[3] of typhoid fever outbreak at Copley, when a meadow was irrigated with the brook water containing the sewage of Halifax.

The negative evidence is, however, so strong as to justify the view that the effluvia from a well-managed sewage farm do not produce typhoid fever or dysentery, or any affection of the kind. In a case at Eton, in which some cases of enteric fever were attributed to the effluvia, Dr. Buchanan discovered that the sewer water had been drunk; this was more likely to have been the cause.

With regard to the second point, the spread of entozoic diseases by the carriage of the sewer water to the land was at one time thought probable, though as solid excreta from towns have been for some years largely employed as manure, it is doubtful whether the liquid plans would be more dangerous. The special entozoic diseases which, it is feared, might thus arise, are *Tape-worms*, *Round worms*, *Trichina*, *Bilharzia* and *Distoma hepaticum* in sheep. Cobbold's latest observations show that the embryos of *Bilharzia* die so rapidly that, even were it introduced into England, there would be little danger. The *Trichina* disease is only known at present to be produced in men by the worms in the flesh of pigs which is eaten, and it is at least doubtful whether pigs receive them from the land. There remain, then, only *Tape-worms* and *Round worms* for men and *Distoma hepaticum* for sheep to be dreaded. But with regard to these, the evidence at present is entirely negative; and until positive evidence is produced, this argument against sewage irrigation may be considered to be unsupported.

The third criticism appears to be true. The land may become swampy, and the adjacent wells poisoned, and disease (ague[4] and perhaps diarrhœa and dysentery) be thus produced. But this is owing to mismanagement, and when a sewage farm is properly arranged it is not damp, and the wells do not suffer.

[1] Carpenter, various papers and essays on this subject drawn from the experience of Croydon Sewage Farm.

[2] Dr. J. W. Williams, Brit. Med. Journal, May 11, 1872.

[3] The Sewage Question, p. 190.

[4] There is no ague or any other disease traceable to the sewage irrigation at Craigentinny, near Edinburgh.

Objections to Sewers.

The main objections are as follows:—

1. *That as underground channels, connecting houses, they allow transference of effluvia from place to place.*—The objection is based on good evidence, but it must be said in reply that, if proper traps are put down, and if air-disconnection, in addition, is made between the outside drains and the house pipe, such transference is impossible. The objection is really against an error of construction, and not against the plan as properly carried out. Besides, the objection is equally good against any kind of sewer, and yet such underground conduits are indispensable.

2. *That the pipes break and contaminate the ground.*—This is a great evil, and it requires care to avoid it. But such strong pipes are now made, that if builders would be more careful to make a good bed, and to connect the joints firmly, there would be little danger of leakage, as far as the pipe drains are concerned, and not much damage of the main brick sewers. All pipes, however, ought to be actually and carefully tested after being laid and before being covered in, otherwise it is impossible to ensure their being water-tight, even when everything is sound to all appearance.

3. *That the water supply is constantly in danger of contamination.*—This also is true, and as long as overflow pipes from cisterns are carried into sewers, and builders will not take care to make a complete separation between water pipes and refuse pipes, there is a source of danger. But this is again clearly an error in constructive detail, and is no argument against a proper arrangement.

On the Influence the Construction of Sewers has had on the Death Rate of Towns.

Reference has already been made to the possibility of sewers being the channels by which enteric fevers and cholera have been propagated from house to house, and from which emanations, causing diarrhœa and other complaints, may arise. Admitting the occasional occurrence of such cases, it remains to be seen whether the sanitary advantages of sewers may not greatly counterbalance their defects. The difficulty of proving this point statistically consists in the number of other conditions affecting the health of a town in addition to those of sewerage. Dr. Buchanan [1] has, however, given some valuable evidence on this point, which has been well commented on by Mr. Simon. He inquired into the total death rate from all causes, and the death rate from some particular diseases, in twenty-five towns before and after sanitary improvements, which consisted principally of better water supply, sewerage, and town conservancy. The general result is to show that these sanitary improvements have resulted in a lowering of the death rate in nineteen out of twenty-five towns, the average reduction in these nineteen cases being 10.5 per cent. The reduction in typhoid (enteric) fever was extremely marked, and occurred in twenty-one towns out of twenty-four, the average reduction being 45.4 per cent. in the deaths from typhoid. In three cases there was an augmentation of typhoid fever, but this was manifestly owing to imperfection in the sewerage arrangements; and these cases afford excellent instances of the

[1] Ninth Report of the Medical Officer to the Privy Council, p. 12 et seq. and p. 40.

unfavorable part badly arranged sewers may play in this direction.[1] Soyka[2] has given some interesting statistics of German towns with regard to this point. In Hamburg the typhoid deaths per 1,000 total deaths has fallen from 48.5 to 10.5; in Dantzig, from 26.6 to 2.3. In Frankfort the typhoid deaths per 10,000 living have fallen from 9 to 2; in Munich, from 24.2 to 8.9

Diarrhœa has also been reduced, but not to such an extent; and in some towns it has increased, while typhoid fever has simultaneously diminished.[3] But the term diarrhœa is so loosely used in the returns as to make any deduction uncertain. Cholera epidemics Dr. Buchanan considers to have been rendered "practically harmless." The immense significance of this statement will be at once appreciated. Whether the result is owing solely to the sewerage or to the improved water supply, which is generally obtained at the same time, is not certain. Phthisis, which Dr. Buchanan and Dr. Bowditch[4] find to be so much influenced by dampness of soil, does not appear to have been affected by the removal of excreta *per se*, at least towns such as Alnwick and Beynmawr, which are thoroughly drained, show no lowering in the phthisical mortality. Nor could Dr. Buchanan trace any effect on the other diseases of the lungs.

As far as can be seen, the effect of good sewerage has therefore been to reduce the general death rate, especially by the reduction of deaths from typhoid and from cholera (and in some towns from diarrhœa), but partly, in all probability, by general improvement of the health. The action has been, in fact, very much in the direction we might have anticipated.

It may be observed, that this inquiry by Dr. Buchanan does not deal with the question as between sewers and efficient dry methods of removing excreta (on which point we possess at present no evidence), but between sewerage and the old system of cesspools.

Modifications of the Wet Method of Removing Excreta.

The Separate System.

By this term is meant the arrangement which carries the rain water in separate channels into the most convenient water-course.[5] Mr. Ward's celebrated phrase "the rain to the river, the sewage to the soil," is the principle of this plan. Its advantages are that the sewers can be smaller; that the amount of sewer water to be dealt with at the outflow is much less in quantity, more regular in flow, and richer in fertilizing ingredients, and is, therefore, more easily and cheaply disposed of. The grit and *débris* of the roads also are not carried into the sewers; and the storm waters never flood the houses in the low parts of the town.

The disadvantages are, that separate channels and pipes have to be provided for the rain; that the rain from all large cities carries from roofs and from streets much organic *débris* which pollutes streams, and that the

[1] See the case of Worthing (p. 45, Ninth Report, etc., op. cit.), for a striking instance of the spread of typhoid through sewers.

[2] Deutsche Viertelj. für Offl. Ges., Band xiv., Heft 1, 1882, p. 33.

[3] Virchow has called attention to the lessening of typhoid.

[4] Ninth and Tenth Reports of the Medical Officers to the Privy Council. See especially Dr. Buchanan's Report in the last-named work, p. 57.

[5] On this subject the works of Mr. Menzies, who first described this plan, and of Colonel Ewart, R.E. (Report on the Drainage of Oxford, Eton, Windsor, and Abingdon, 1868), will be found very useful.

scouring effect of the rain on sewers is lost, though this last is a very questionable objection.

The adoption of one or other system will probably depend on local conditions. If a town in Europe lies low, and it is expensive to lift sewage; if land cannot be obtained; or if the natural contour of the ground is very favorable for the flow of rain in one direction, while it is convenient to carry the sewage in another, the separate system would be the best. So also in the tropics, with a heavy rainfall and a long dry season, the providing of sewers large enough to carry off the rain would be too expensive for all except the richest cities, and the disposal of the storm water would be difficult.

In all cases in which rain enters the sewers, some plan ought to be adopted for storm waters.[1] If irrigation is the plan carried out, the sewer water becomes so dilute and so large in quantity in storms, that the application to land is usually suspended, and the sewer water is allowed to pass at once into streams.

In this way the evil which irrigation is intended to prevent is produced, though, doubtless, the sewer water is highly dilute. In London, the storm waters mingled with sewage are allowed to flow into the Thames, special openings being provided.

The Interception System.

In many of the continental cities the fluid and solid excreta fall into a receptacle with perforated sides or bottom, so that the fluid part drains away and the solid is retained, and is removed from time to time. Such a plan may keep the sewers free from deposit, but has the great disadvantage of retaining large collections of excreta close to and in many cases immediately under or in the cellars of houses, and no ventilation can entirely remove all effluvia.

An improvement on this plan is a method proposed by Mr. Chesshire, of Birmingham. He places outside the house, in any place where access is easy, a comparatively small box, connected by trapped pipes with the water-closet at one end, and the sewer at the other. The lid of the box is fixed down with concrete or putty, so that the access of air is stopped. Across one end of the box is a single or double strainer, which allows the urine and water to pass, but retains the solids. From time to time the box is lifted out, carted away, and another is inserted. The solid matter is almost free from odor, as the limited access of air hinders putrefaction.

The difficulty about this plan is the occasional blockage of the strainer, so that the solid matters remain wet, and may soon fill the box, so that the lid may be forced off. The liquid which flows from the box is of course highly impure with excreta, but the retention of the solids prevents blockage of the sewers. At present it can only be said that this plan has not been yet practically established on the large scale, but is well worthy of extended trial, particularly in cases where the difficulties of irrigation are great.

Water-Closets and Water-Troughs.

Water-Closets.—The pan of the closet is usually a cone in earthenware (which is better than metal), and a siphon or flap valve below. In addition, there are numerous contrivances for flushing the pan and siphon,

[1] Plans for this purpose are figured and described in the works on Sanitary Engineering, by Baldwin Latham and Bailey Denton.

and for preventing the escape of the air from the soil pipe into the house.[1] The soil pipe is usually of cast lead; but both lead and iron are easily eaten through, as shown by Drs. Fergus and N. Carmichael, and earthenware pipes, if strong and well joined, would be preferable.[2]

The points to be looked to in examining closets are—1st, that the pan is nearly a cone, and not a half circle with a flat bottom; 2d, that the amount and force of water is sufficient to sweep everything out of the siphon; 3d, that the soil pipe is ventilated beyond the siphon, by being carried up full-bore to the top of the house; 4th, that the junction of siphon and soil pipe and the lengths of the soil pipe are perfect.

With respect to water, a pipe from the house cistern frequently leads to the closet; but if so, there is danger of gas rising through the pipe. There should be a special small cistern for the use of the closet. What are termed water-waste preventers are now commonly used, fed either by a cistern or by constant supply. They are boxes which are emptied by a valve into the pan, and are then refilled. There are many kinds, but perhaps the best are those that work by siphon action, brought into play by pulling a wire. The amount of water should not be less than two gallons, and the fall should not be less than 3 or 4 feet, so as to insure thorough scouring of the soil pipe.[3]

The ventilation of the soil pipe is a matter of importance, as the water from the pan suddenly displaces a large body of foul air, which rises through the siphon as the water flows. The best plan is to carry up the soil pipe full-bore to the roof, far from any windows. It is well also to have a second pipe from the crown of the siphon to the ventilating pipe, in order to prevent the unsiphoning of the trap (see Fig. 84). Air is supplied by a grating below, as in Buchan's and other disconnecting traps, or (as in Banner's plan) by drawing air from another shaft carried up the house. The currents in the two shafts are determined by reversed cowls. In some cases it is proposed to draw the air *down* the soil pipe and *up* another pipe.

The simple hopper closet, or some form of "wash-out" closet, with a siphon trap below, is the safest; but there are some good forms of valve closet in the market. They are, however, too frequently made with overflow pipes passing into the soil pipe. These, although siphon trapped, are apt to be sucked dry. They are thus dangerous, and they are really unnecessary, for a well-made siphon pan rarely overflows. If it does, it is better to receive the overflow on to a safe under the closet, from which the water flows out through a pipe to the open air, such pipe acting as a warning pipe. The old *pan*-closet, with its filthy *container* and D trap, ought to be absolutely discarded.

The position of the closet is a matter of great moment. If possible, it should always be in an outbuilding, or a projection, with thorough ventilation between it and the house. In two-storied buildings it might be put in a small third story in the roof, and well ventilated above. The windows in a closet ought always to open quite to the ceiling.

[1] Mr. Eassie's work, Healthy Houses, gives a good account of the various kinds of closets.

[2] In his work on Sanitary Arrangements for Dwellings, Mr. Eassie does not approve of earthenware pipes, preferring the strongest cast lead to any other.

[3] The Army Sanitary Committee (On Sanitary Appliances, Blue Book, 1871, p. 17) state that the amount of water used in the water-closets in the army is, for Green's closet, between ½ gallon and 1 gallon for each time of use; Underhay's, Lambert's, and the pan-closet, from 1 to 1½ gallon; and for Jenning's closet, usually the same, or in some stations 3 gallons.

In all cases, a tube should pass from the top of the closet to the outer air, and, if the closet is in a bad situation, the tube should be heated by a gas-jet.

It is a bad plan to have the pull-up handle covered by the lid ;[1] it should be able to be pulled up when the lid is shut, or the shutting of the lid should open the water-waste preventer cistern. In wash-out closets the flush is often obtained by pulling a wire like a bell-pull, as mentioned above.

The plan of placing closets in the basement should be entirely given up; closet air is certain to be drawn into the house.

Water-Troughs or *Latrines.*—These are very strong earthenware or cast-iron receptacles, which are about half full of water. The excreta drop into the water, and once or twice a day a valve is raised, and the water and excreta pass into a drain. There is usually a receptacle into which fall bits of bricks, towels, or other things which are thrown in, so that they are stopped and fished out when the trough is emptied, and do not pass into the drain. The amount of water in the water-latrines used in some barracks is about 5 gallons per head daily, so that the plan is not economical of water, but, as it avoids all loss by the dripping in closets, there is probably no great excess of expenditure. It is a good plan to have a flexible hose attached to the water pipe, so as to wash thoroughly the seats and partitions every day.

The chief objection to this plan has been the labor which is necessary to empty the trough ; but this may be obviated by the use of automatic flush tanks, discharging periodically. On the other hand, there is saving of expenditure in repairs to water-closets.[2]

In judging of the value of a water-trough, the amount of water, the surface exposed to evaporation, and the completeness of the flushing, are the points to look to.

Dry Methods.[3]

The use of sewers and removal by water are in many cases impracticable. A fall cannot be obtained ; or there is insufficient water ; or the severity of the climate freezes the water for months in the year, and removal by its means cannot be attempted. Then either the excreta will accumulate about houses, or must be removed in substance daily or periodically. Even when water is abundant, and sewers can be made, many agriculturists are in favor of the dry system, as giving a more valuable fertilizing product ; and various plans are in use.

It is not necessary to consider here the employment of cesspools, dead-

[1] In Dr. Aldridge's patent the handle cannot be pulled up until the lid is shut down ; there is also arrangement for carrying off foul gas by means of a pipe communicating with the outer air, the lid itself being air-tight round the rim of the seat.

[2] In the army two kinds of latrines (Macfarlane's, of cast-iron, and Jenning's, of earthenware) have been in use for about twenty years. The Army Sanitary Committee (On Sanitary Appliances introduced into Barracks, Blue Book, 1871, p. 14) state that out of 183 barracks only 53 have been charged with repairs, and the average expenditure on these 53 has been 12s. per barrack annually for Macfarlane's, and 18s. 9d. per barrack for Jenning's latrine, and nearly the whole of these expenses have been caused by articles thrown carelessly into the latrines.

[3] On the dry methods of removal a very good paper has been published by Dr. Buchanan and Mr. Radcliffe (Twelfth Report of the Medical Officer to the Privy Council, 1870, pp. 80 and 111) ; also another by Mr. Netten Radcliffe (Report on certain Means of preventing Excrement Nuisances in Towns and Villages, New Series, No. 2, 1874).

wells, etc., as such plans must be considered quite unsanitary, and should be invariably discontinued. If excreta are ever allowed to accumulate, it should be in properly prepared receptacles, and after admixture with deodorants.

Removal without Admixture.

In some cases the solid and liquid excreta pass into boxes or tanks, which are emptied daily, or from time to time, and the sewage is at once applied to land without further treatment. In Glasgow the excreta from one part of the town, containing 80,000 people, are now removed every day without admixture, except with the garbage from the houses, and are sent long distances at a profit.[1] If the removal can be made daily, the plan is a good one; the manure should not be applied in the immediate neighborhood of dwellings, and the Barrack Commissioners have ordered that it shall not be put on land nearer barracks than 500 yards.

In some towns in the north of England (Salford, Halifax, Nottingham), the receptacles are lined with some absorbent material (refuse of cloth manufactures), and at Aldershot with stable litter, intended to absorb the urine (Goux system); in other cases the urine is carried off by a pipe into a drain; the intention being, in both cases, to make the fecal matter drier, and to delay decomposition.

In others, the soil being removed daily, or at short intervals, is taken to a manufactory, and there subjected to manipulations which convert it into a manure.

Under the term "Poudrette," manufactories of this kind have been long carried on in France, though they are said not to be very profitable.[2] At present, however, a portion of the nitrogen of the urea is converted into ammonia, and is united with sulphuric acid, and comes into the market as sulphate. In England, also, there have been several manufactories.

There have been great discussions as to the salubrity of the French poudrette manufactories, and the evidence is that they are not injurious to the workmen or to the neighborhood, although often disagreeable. But the poudrette can take on a kind of fermentation which renders it dangerous, and Parent-Duchâtelet has recorded two cases of outbreaks of a fatal fever (typhoid?) on board ships loaded with poudrette. In the case of the Eureka Company in England no bad effect was produced on the health of the men.

Admixture with Deodorizing and Anti-putrescent Substances.

Usually, however, some deodorizing substance is mixed with the excreta before they are removed from the house, and they are then at once applied to land without further preparation. Mr. Moule's advocacy of the use of dried earth has brought into prominent notice the great deodorizing powers of this substance, and perhaps no suggestion of late years has had more important consequences. The various substances employed to prevent odor and decomposition are as follows:—

[1] At Carlsruhe, Mannheim, Rastadt, and Bruchsal the excreta are removed in boxes holding about 116 cubic feet (Prussian) every evening. From an experience of eighteen years (1851–1868), the excreta of 6,351 men (mean strength) returned 7,628 florins per annum, of about 1s. 11d. English money per head. In Bruchsal it was 1s. 1d., and in Mannheim 2s. 6d. per head. This rich manure has converted the sandy wastes into fertile corn-fields.

[2] Nearly all the solid excreta of Paris are dealt with in the same way, at the great depôt of Clichy-la-Garenne.

1. *Coal and Wood Ashes.*—This is a common practice in the north of England, and closets are made with hinged flaps or seats, so that the coal ashes may be thrown on the sewage. Sometimes screens are used, so that the large cinders are held back, and can again be used for firing. In some towns there are receptacles (middens) intended both for excreta and ashes; sometimes these are cemented, but are usually porous, and there may be a pipe leading into a sewer so as to dry them. The midden system is a bad one; even with every care, the vast heaps of putrefying material which accumulate in some of our towns must have a very deleterious influence on the health, and the sooner all middens are abolished the better. The deodorizing effect of coal ashes is very slight. The mixture of coal ashes and excreta usually finds a sale, but the profit is much greater if no ashes are mixed with it. Wood ashes are far more powerful as deodorizers, but it is not easy in this country to have a proper supply.

2. *Charcoal.*—There is no better deodorizer than charcoal.[1] Animal charcoal is too expensive, and peat charcoal is cheaper; according to Danchell, 3 ounces of peat charcoal are equal to 1½ lb of earth; and this author states that the cost of charcoal for a family of six persons would only be 1s. 6d. per month. A plan has been proposed by Mr. Stanford,[2] and is in use at Glasgow, which may obviate the difficulty of price. Mr. Stanford proposes to obtain charcoal from sea-weed; the charcoal is cheap, and remarkably useful as a deodorizer. After it has become thoroughly impregnated with fæces and urine, the mixture is re-carbonized in a retort, and the carbon can be again used; the distilled products (ammoniacal liquor, containing acetate of lime, tar, gas) are sufficient to pay the cost, and it is said even to give a profit.

The closet used with this carbon is, in principle, similar to Moule's earth closet, with various improvements for more thoroughly mixing the charcoal and sewage.

The advantages claimed by Mr. Stanford's process are the complete deodorizing effect; the small amount of charcoal required as compared with dry earth (three-fourths less required); the value of the dry manure, or of the distilled products, if the mixture is reburnt; and, in the last case (burning), the complete destruction of all noxious agencies. In using it the mixed charcoal and sewage may be stored for some months without odor in some convenient receptacle outside, but not under the house; and Mr. Stanford states that all the house urine can be also allowed to flow into this receptacle. The reburning of the mixture can be done in a gas retort, or a special retort is built for the purpose; the charcoal left in the retort is returned to the house.

3. *Earth.*—Since the Rev. Mr. Moule pointed out the powerful deodorizing properties of dried earth, many different closets have been proposed.

Mr. Moule's earth closet consists of a wooden box, with a receptacle below, and a hopper above, from which dried earth falls on the sewage when the plug is pulled up. The earth is previously dried, and about 1¼ to 1½ lb of the dried earth per head daily is the usual allowance. For a single house, the earth can be dried over the kitchen fire; but if a village is to be supplied, a small shed, fitted with tiles, below which smoke pipes from a small furnace pass, is required. The earth used in the closet is sufficient to deodorize the solid excreta, and the portion of the urine

[1] At Kreilingen, in Holland, a pail system is in use, where charcoal is employed made from burning town refuse. It appears to yield a product of sufficient value to pay for itself.

[2] Chemical News, June and October, 1869, and February, 1872.

passed with them; but the rest of the urine and house water has to be carried off in pipes, and disposed of in some other way. The receptacle is emptied from time to time, and the mixture is stored until it can be applied to land.

The advantages of this plan are obvious; its disadvantages are the necessity of collecting, and drying, and storing the earth, which for cottagers who have little space, and possibly no means of getting earth, is a serious matter. The supply of dried earth to large towns is almost a matter of impossibility, so large is the amount required.[1] Again, the attention necessary to prevent the house water being thrown in, and to remove the soil at sufficiently short periods, sometimes militates against the success. To obviate these disadvantages, some modifications have been introduced into Moule's closet; one side of the receptacle may be covered with a grating, leading to a pipe, so that all fluids drain away, and the house water can be thrown in. In another plan, as in Taylor's improved closet, the urine is carried away without mixing at all with the solid excreta. Sometimes the urine thus separated is led into another box of earth, and is thus more easily disposed of, if there are no means of taking it entirely away; or it is passed into a tank, and then used as liquid manure. In another modification (Moser's original form), a partition along the front holds some absorbent substance (sawdust, straw), into which the urine passes, and the solids are thus kept dry. This separation of the urine and solids certainly appears to be an improvement. Dr. Carpenter, of Croydon, reports well of these closets.[2]

The best kind of earth is clay, marl, and vegetable humus; when dried, the clay is easily powdered. Chalk and pure sand are of little use.

The earth system is coming into great use in India, and is carried out with great attention to detail. In those European stations where water is not procurable, Mr. Moule's invention has been a boon of great value, and medical officers have stated that nothing has been done in India of late years which has contributed so much to the health and comfort of the men.[3] The plan of separating the urine from the fæces has been strongly advocated by Dr. Cornish, of Madras, and would no doubt be attended with great advantages in India if there are means of disposal of the urine. The chief difficulty in the European barracks in India is felt during the rainy seasons, when the mixed excreta and earth cannot be kept sufficiently dry.

In the case of natives of India, however, a serious difficulty arises in the use of the earth system, in consequence of the universal use of water for ablution after using the closet. Every native takes with him a small vessel holding 10 to 20 ounces of water, so that a large amount of fluid has to be disposed of. The usual earth closet does not suffice for this. Mr. Charles Turner, C.E., of Southampton, contrived a closet suitable for the native family;[4] it is unfortunately too costly, and possibly a simple iron

[1] For workhouses, prisons, barracks in country places, where there is plenty of labor, and no difficulty in obtaining and afterward disposing of the earth, the plan is most perfect. So also for small villages, if some central authority arranges for the supply of earth, and for the removal of the used soil. For a good statement of the advantages of the earth system, see Dr. Hawksley's paper in the Report of the Leamington Congress on the Sewage of Towns.

[2] Bailey Denton, op. cit., p. 102.

[3] An account of the Bengal arrangements will be found in the 2d edition of this work, p. 329, but the plans have been much altered.

[4] This was done at the suggestion of Dr. Niven, of Bombay. Mr. Turner's closet is described and figured in Dr. Parke's Report on Hygiene for 1867, Army Medical Report for 1866, published 1868, vol. iii., p. 307.

box, with a pipe to carry off the urine and ablution water, would be better suited for the poorer classes.

It appears from the observations of Mr. Fawcus, at the jail of Alipore, that more earth must be used for vegetable than for animal feeders; the experiment gave 5.1 lb avoir. (2½ seers) of undried earth for the daily evacuation of a vegetable-feeding Hindoo. The urine discharge (2 lb) required 8.2 lb of earth. The earth was efficacious in proportion to the vegetable organic matter or humus. In the experiments in this country the clayey matters (silicates of alumina) have seemed to be chiefly useful. In Indian jails and some cantonments the trench system is used; shallow (1 to 1½ foot deep) trenches are dug in a field, and earth is thrown over the excreta; when the trenches are full, the whole is ploughed up, and vegetables are at once planted, trenches being dug elsewhere; after two or three crops this portion of the field may be used again. Great importance is attached to the early and repeated cropping of the ground.[1]

4. *Deodorizing Powders.*—Instead of charcoal or earth, M'Dougall's or Calvert's *carbolic acid powders* may be used, and this plan has been largely adopted in some Indian stations. A comparatively small quantity is required, but the smell of the carbolic acid and the cost are somewhat against the plan. Dr. Bond's preparations of Terebene, viz., the Terebene powder, Cupralum, etc., are very efficacious, and have a pleasant odor. Langton-Jones' Universal Disinfecting Powder is inodorous, but not very powerful.

5. *Sawdust* mixed with *sulphuric* or *carbolic acid.*—The mixture of sulphuric acid and sawdust has been found to have little efficacy; the carbolic acid has the disadvantage of the odor which adheres to the clothes. Chloralum powder is also mixed with sawdust, and is moderately efficacious.

6. In Germany, *Süvern's* deodorizer (a mixture of lime, magnesium chloride, and coal-tar) is much used. The *Müller-Schür* deodorizer is composed of 100 lb of lime, 20 lb of powdered wood charcoal, 10 lb of peat powder or sawdust, and 1 lb of carbolic acid containing 60 to 70 per cent of real acid. After mixing, the mass is put under cover for a night to avoid any chance of self-combustion, and when it is dry it is packed in barrels. *Lueder* and *Leidloff's* powder, consisting of ferric sulphate, ferrous sulphate, calcium sulphate, and a little free sulphuric acid, is also much used. It is moderately successful.

Arrangement of Closets on the Dry Plan.

As the excreta after being mixed with the deodorizer are in most cases kept for some days or even weeks close to the house, the same rules as to position and construction of closets should be employed as in the case of water-closets. The closet should never be in the basement, but in the roof, or, better still, in a detached building or semi-detached, and with thorough ventilation between it and the house; there should be a pipe leading at once to the outer air from the closet, and one from the receptacle.

[1] Two objections have been made to the dry earth system:—1. It is almost impossible to get rid of a certain amount of smell, even with deodorants. 2. The product is not very valuable, according to Dr. Gilbert's analysis, not so valuable as good garden mould, even after the earth has been twice used. The chief value is therefore a sanitary one.

The receptacle itself is usually movable; but if not, it should be most carefully cemented, so that no leakage may occur.

With these precautions no odor will be perceived; but it is still very desirable that the removal of the soil should be as frequent as possible. In country houses there is no difficulty, but in towns the removal can seldom be more frequent than once a week, and often is only once a month.

The forms of the closet itself are numerous. Those applicable to the earth plan have been already noticed. Colonel Synge, R.E., has patented a closet for Mr. Stanford's charcoal process (the Alver appliance for dry deodorants). In Germany and the north of Europe, where the dry removal, but without admixture with deodorant powders, is in much use, there are various closets in which the urine and fæces are separated.[1] The "air-closet" of Mehlhouse is said to be a good arrangement for houses. The urine runs into a porcelain funnel fixed on the front wall of the pan, and then into an iron vessel, from which it can readily be removed through a valve; the solids fall into an iron receptacle at the back part of the pan. A discharge tube passes from the back and top part of this receptacle into a chimney. Two openings in the front wall, which can be closed by valves, can be used as inlets for the air. If a hopper with charcoal or dried earth were attached to this closet, it would be almost identical with Taylor's improved closet.[2]

Carbonization.

In 1869, Mr. Hickey,[3] of Darjeeling (Bengal Presidency), proposed to carbonize the sewage in retorts, either with or without previous admixture with charcoal. Almost at the same time Mr. Stanford[4] proposed the plan already referred to, of the addition of sea-weed charcoal, and subsequent distillation.

In India the difficulty of obtaining a remunerative price for the ammoniacal products, and the large cost of the apparatus necessary for working the plan, have been unfavorable to its success. Carbonization is now being tried in this country, and may possibly be commercially successful. Experience only can show if it is so; but if it will return a profit, there can be no question that it is an excellent plan in a purely sanitary point of view. The chief money difficulty in the process is the large amount of water which has to be driven off, which greatly increases the expense.

In Manchester Fryer's patent method is in operation, and it is also being applied, in whole or in part, at Birmingham and at Leeds. It consists of a Destructor, which reduces to slag all the more bulky town refuse, such as cinders and ashes, broken earthenware and glass, which cannot be dealt with except by being accumulated in a rubbish heap. This slag is ground, mixed with lime, and sold as mortar. The apparatus is so arranged that none of the heat is lost, while the heated products of combustion pass over

[1] Roth and Lex (op. cit., p. 454) give a good description of these. See also for some good remarks, Pettenkofer's paper on the "Sewerage of Bâle" (Zeitsch. für Biologie, Band iii., p. 273).

[2] Dr. Bond has also invented a good form of self-acting closet, which separates the urine and fæces. At Manchester and Salford the cinder-sifting closet of Mr. Morrell is in use.

[3] The Carbonization or Dry Distillation System of Conservancy, by W. R. S. Hickey, C.E.; with a note on Dry Sewage, by F. J Mouat, M.D. Darjeeling, 1869.

[4] A Chemist's View of the Sewage Question, Chemical News, June to October, 1869.

fresh portions of material and prepare it for combustion. The mass is reduced in bulk to one-third. Other refuse, such as condemned food, vegetable garbage, street sweepings, and the like, are reduced to charcoal in another apparatus called the Carbonizer. The carbon thus produced is used for disinfecting purposes, for decolorizing the waste water from factories, etc. The excreta proper it is proposed to collect in pails and reduce to small bulk, by drying in a closed apparatus, called the Concretor; the ammonia being fixed by the sulphuric acid fumes produced by the other processes. By this means the contents of the pails are reduced to one-twelfth, and a valuable manure obtained, which may be either in the form of poudrette or mixed with a little charcoal.

The Pneumatic Air Plan[1] (Aspiration Plan).

A Dutch engineer, Captain Liernur, proposed some years since an entirely novel plan. No water or deodorizing powders are used; the excreta fall into a straight earthenware pipe, leading to a smaller iron siphon pipe, from which they are extracted periodically by exhaustion of the air. The extracting force which can be used (by an air-pump worked by a steam engine), is said to be equal to a pressure of 1,500 lb per square foot, which is sufficient to draw the excreta through the tubes with great rapidity. The plan has been tried on the small scale at Prague, Rotterdam, Amsterdam, Leyden, and Hanau, also at Brünn, Olmutz, and St. Petersburg, and the opinions concerning it are very various. It does not render sewers unnecessary; indeed, the system contemplates an arrangement of sewers for slop and other waters.

Shone's Ejector System.—This is an opposite plan to Liernur's, the agent

[1] The Sewage Question, by F. C. Krepp, London, 1867. This book was written for the purpose of bringing the Liernur plan before the public, and some parts of it must be taken with limitation.

Reports in Deutsche Vierteljahrs. für öffentl. Gesundsheitspfl., Band iii., p. 313 (1871).

Ibid., Band iii., p. 312.

Report of Kauff and Esser, in Deutsche Viertelj. für öff. Gesundsheitspfl., Band iv., p. 316. These gentlemen were sent from Heidelberg to investigate the plan. Reports of Messrs. Schröder and Lorent (Ibid., Band iv., p. 486). In this Report is a good technical and financial account.

Ballot (Medical Times and Gazette, February 15, 1873) spoke favorably of it, and considered it to have been a decided success in Amsterdam and Leyden. Gori, on the other hand (Med. Times and Gazette, March 8, 1873), replied to Ballot, denied that this is the case, and declared that in Amsterdam all with one consent say, "It is impracticable." Ballot adheres, however, to his statement.

I saw the system at work in Leyden in September, 1876, when much of its results and details was explained to me by the late Professor Boogaard, and again in Amsterdam in 1879, with Captain Liernur himself. It seemed very effectual, and there was a total absence of odor, although I was present in some of the closets at the moment that the contents were sucked away by the apparatus. In Leyden the material is sold in barrels in the liquid form; but at Dordrecht, where the newest and most complete works are, it is made into poudrette, which is said to pay. In this country, Mr. Adam Scott has done his best to bring it to public notice (see his papers in the Builder, Sanitary Record, Public Health, etc.). He considers that it has been shown by five years' experience in Holland, that the pneumatic system, by removing excrement without any possible pollution of air, soil, or water, has banished typhoid and diphtheria, as well as cholera and any diseases that are conveyed by the discharge from the intestines. The Committee on Town Sewage (Mr. Rawlinson and Mr. C. S. Reade) speak most disparagingly of it, more so, indeed, than seems warranted by all the evidence. On the other hand, the patent for Austria and Hungary has been purchased by the Vienna Joint-Stock Agricultural Society, who consider it a success, both hygienically and financially.—(F. de C.).

being compressed air instead of exhaustion. It has been applied at Wrexham and at Eastbourne, and is well spoken of.

Comparison of the Different Methods.

Much controversy has arisen on this point, though it does not appear that the question of the best mode of removing excreta is really a very difficult one. It is simply one which cannot be always answered in the same way.

It will probably be agreed by all that no large town can exist without sewers to carry off the foul house water, some urine and trade products, and that this sewer water must be purified before discharge into streams. The only question is, whether fecal excreta should also pass into the sewers.

It will also be, no doubt, admitted that no argument ought to be drawn against sewers from imperfection in their construction. The advocate of water removal of solid excreta can fairly claim that his argument presupposes that the sewers are laid with all the precision and precaution of modern science ; that the houses are thoroughly secured from reflux of sewer air ; that the water-closets or water-troughs are properly used ; and that the other conditions of sufficient water supply and power of disposal of the sewer water are also present. If these conditions are fulfilled, what reason is there for keeping out of the sewer water (which must, under any circumstance of urban life, be foul) the solid excreta, which, after all, cannot add very greatly to its impurity, and do add something to its agricultural value?

That it is not the solid excreta alone which cause the difficulty of the disposal of sewer water is seen from the case of Birmingham. That town is sewered ; it contains nearly 400,000 inhabitants, and is in the greatest difficulty how to dispose of its sewer water ; yet the solid excreta of only 6 per cent. of the inhabitants pass into the sewers, while the solid excreta of the remainder are received into middens.[1] The problem of disposal is as serious for Birmingham as if all the excreta passed in.

That great difficulty, in fact, consists not so much in the entrance of the solid excreta into sewers, as in the immense quantity of water which has to be disposed of in the case of very large inland towns with water-closets. If water-closets are not used, the amount of water supplied to towns, and that of sewer water, are considerably lessened.

Looking to all the conditions of the problem, it appears impossible for all towns to have the same plan, and the circumstances of each town or village must be considered in determining the best method for the removal of excreta. London is particularly well adapted for water sewerage, on account of the conformation of the ground north of the Thames, of the number of streams (which have all been converted into sewers), and of the comparative facility of getting rid of its sewer water. The same may be said of Liverpool and many other towns. In Birmingham, on the other hand, the inland position, the price of land, and the comparative difficulty of getting water, seem to render other plans more desirable. If it had been possible, years ago, to act with our present knowledge, and to devise a scheme for Birmingham, it would have been best to have taken the rain-

[1] Report of the Birmingham Sewage Inquiry Committee (1871), Summary, p. 11. It should, however, be added that two-thirds of the middens drain into the sewers, *i.e.*, allow urine and some diffluent fecal matter to pass in. In 1875, 128,512 tons of midden refuse were removed and sent to country depôts, to be afterward disposed of to farmers.

fall into the Rea; to have had the sewers merely for house and trade water (which would have given a manageable amount for filtration through land); and to have introduced some deodorizing dry plan for the solid excreta, and for a part of the urine, with short periods of removal.

In many towns where land is more available, the immediate application to land, either by filtration or irrigation, may be evidently indicated by the conditions of the case, while in others precipitation may have to be resorted to before application to land. It does not appear that precipitation should in all cases precede irrigation or filtration, though mechanical arrest of the large suspended matters is necessary. There may be some towns, again, in which the impossibility of getting water or land may necessitate the employment of dry removal; and this is especially the case with small towns and villages, where the expense of good sewers and of a good supply of water is so great as to render it impossible to adopt removal by water. It may, indeed, be said that, in small towns in agricultural districts, the dry removal, if properly carried out, will be the best both for the inhabitants and for the land.

The view here taken that no single system can meet all cases, and that the circumstances of every locality must guide the decision, is not a compromise between opposing plans, but is simply the conclusion which seems forced on us by the facts of the case. It does not invalidate the conclusion already come to, that, where circumstances are favorable for its efficient execution, the water sewage plan (with or without interception of rainfall) is the best for large communities.

CHAPTER XI.

WARMING OF HOUSES.

The heat of the human body can be preserved in two ways :—

1. The heat generated in the body, which is continually radiating and being carried away by moving air, can be retained and economized by clothes. If the food be sufficient, and the skin can thus be kept warm, there is no doubt that the body can develop and retain its vigor with little external warmth. In fact, provided the degree of external cold be not too great (when, however, it may act in part by rendering the procuring of food difficult and precarious), it would seem that cold does not imply deficiency of bodily health, for some of the most vigorous races inhabit the cold countries. In temperate climates there is also a general impression that for healthy adults external cold is invigorating, provided food be sufficient, and if the internal warmth of the body is retained by clothing.

2. External heat can be applied to the body either by the heat of the sun (the great fountain of all physical force, and vivifier of life), or by artificial means, and in all cold countries artificial warming of habitations is used.

The points to determine in respect of habitations are—

1st. What degree of artificial warmth should be given?

2d. What are the different kinds of warmth, and how are they to be given?

SECTION I.

DEGREE OF WARMTH.

For Healthy Persons.—There appears no doubt that both infants and old persons require much artificial warmth, in addition even to abundant clothes and food. The lowering of the external temperature, especially when rapid, acts very depressingly on the very young and old; and when we remember the extraordinary vivifying effect of warmth, we cannot be surprised at this.

For adult men of the soldier's age, who are properly fed and clothed, it is probable that the degree of temperature of the house is not very material, and that it is chiefly to be regulated by what is comfortable. Any temperature over 48° up to 60° is felt as comfortable, though this is dependent in part on the temperature of the external air. It seems certain that for healthy, well-clothed, and well-fed men we need not give ourselves any great concern about the precise degree of warmth.

For children and aged persons we are not in a position at present to fix any exact temperature; for new-born children a temperature of 65° to

70°, or even more, may be necessary, and old people bear with benefit a still higher warmth.[1]

For Sick Persons.—The degree of temperature for sick persons is a matter of great importance, which requires more investigation than it has received. There seems a sort of general rule that the air of a sick-room or hospital should be about 60° Fahr., and in most Continental hospitals, warmed artificially, this is the contract temperature; but the propriety of this may be questioned.[2]

There are many diseases greatly benefited by a low temperature, especially all those with preternatural heat. It applies, almost without exception (scarlet fever?), to the febrile cases in the acute stage, that it is desirable to have the temperature of the air as low as 50°, or even 45° or 40°. Cold air moving over the body is a cooling agent of great power, second only, if second, to cold effusion; nor is there danger of bad results if the movement is not too great. The Austrian experiments on tent hospitals[3] show conclusively that even considerable cold is well borne. Even in the acute lung affections this is the case. Pneumonia cases do best in cold wards, provided there is no great current of air over them. Many cases of phthisis bear cool air, and even transitions of temperature, well, provided there be no great movement of air. On the other hand, it would appear that chronic heart diseases with lung congestion, emphysema of the lungs, and diseases of the same class, require a warm air, and perhaps a moist one. With respect to the inflammatory affections of the throat, larynx, and trachea, no decided evidence exists; but the spasmodic affections of both larynx and bronchial tubes seem benefited by warmth.

In the convalescence, also, from acute disease, cold is very badly borne; no doubt, the body, after the previous rapid metamorphosis, is in a state very susceptible to cold, and, like the body of the infant, resists external influences badly. Convalescents from fever must therefore be always kept warm. This is probably the reason why it is found inadvisable to transfer febrile patients treated in a permanent hospital to convalescent tents, although patients treated from the first in tents have a good convalescence in them, as if there were something in habit.

SECTION II.

DIFFERENT KINDS OF WARMTH.

Heat is communicated by radiation, conduction, and convection. The latter term is applied to the conveyance from one place to another of heat by means of masses of air, while conduction is the passage of heat from one particle to another—a very slow process. Practically, conduction and convection may be both considered under the head of convection.

[1] It is singular, however, that in some old people the temperature of the body is higher than normal (John Davy). Is there, then, a difference in the amount of external heat required in different persons?

[2] It is owing to this rule that in French hospitals, artificially ventilated and warmed by hot air, the amount of air is lessened and its temperature heightened in order to keep up the contract temperature of 15° C. (= 59° F.) The air is often then close and disagreeable. A safe general rule is never to sacrifice fresh air to temperature, except in the most extreme cases. Of course, cold currents of air are to be avoided if possible, but it is safer, as a rule, to let the general temperature go down, rather than diminish the change of air. In most cases it can be compensated for by additional covering.

[3] See Report on Hygiene in the Army Medical Reports, vol. iv., by Dr. Parkes. The Prussians have also lately made great use of tents in the summer.

Radiant heat has been considered by most writers the best means of warming; it heats the body without heating the air,[1] and of course there is no possibility of impurity being added to the air.

The disadvantages of radiant heat are its cost, and its feebleness at any distance. The cost can be lessened by proper arrangement, but the loss of heat by distance is irremediable. The effect lessens as the square of the distance—*i.e.*, if, at 1 foot distance from the fire, the warming effect is said to be equal to 1, at 4 feet distance it will be sixteen times less. A long room, therefore, can never be warmed properly by radiation from one centre of heat only.

It has been attempted to calculate the amount of air warmed by a certain space of incandescent fire, and 1 square inch has been supposed sufficient to warm 8.4 cubic feet of air. But much depends on the walls, and whether the rays fall on them and warm them, and the air passing over them.

Radiating grates should be so disposed as that every ray is thrown out into the room. The rules indicated by Desaguliers were applied by Rumford. Count Rumford made the width of the back of the grate one-third the width of the hearth recess; the sides then sloped out to the front of the recess; the depth of the grate from before backward was made equal to the width of the back. The sides and back were to be made of non-conducting material; the chimney throat was contracted so as to lessen the draught, and insure more complete combustion. The grate was brought as far forward as possible, but still under the throat.

The open chimney, which is a necessity of the use of radiant grates, is so great an advantage that this is *per se* a strong argument for the use of this kind of warming, but, in addition, there can be little doubt that radiant heat is really the healthiest.

Still the immense loss of heat in our common English fire-places must lead to a modification, and radiant heat must be supplemented by

Convection and Conduction.

The air is heated in this case by passing over hot stones, earthenware, iron or copper plates, hot water, steam, or gas pipes. The air in the room is thus heated, or the air taken from outside is warmed, and is then allowed to pass into the room, if possible at or near the floor, so that it may properly mingle with the air already there. The heat of the warming surface should not be great, probably not more than 120° to 140° Fahr.; there should be a large surface feebly heated. The air should not be heated above 75° or 80° Fahr., and a large body of air gently heated should be preferred to a smaller body heated to a greater extent, as more likely to mix thoroughly with the air of the room.

It does not matter what the kind of surface may be, provided it is not too hot. If it is, the air acquires a peculiar smell, and is said to be burnt; this has been conjectured to be from the charring of the organic matter. Some have supposed the smell to be caused by the effect of the hot air on the mucous membrane of the nose, but it is not perceived in air heated by the sun. Such air is also relatively very dry, and absorbs water eagerly from all substances which can yield it.

[1] Dr. Sankey has made experiments which show that the temperature of the air of a room heated by radiant heat is really lower than the temperature indicated by the thermometer, because the bulb is warmed by radiation. When this is prevented by enclosing the bulb in a bright tin case the thermometer falls.

If the air is less heated (not more than 75°) it has no smell, and the relative humidity is not lessened to an appreciable extent. Haller's experiments, carried on over six years with the Meissner stove common in Germany, show that there the relative moisture is not lessened with moderate warming,[1] and the same result has been found with the Galton stoves. On the other hand, when the plates are too hot, the air may be really too much dried, and Dr. Sankey states that while he never found the difference between the dry and wet bulbs in a room warmed by radiant heat to be more than 8° Fahr., he has noticed in rooms warmed by hot air a difference of 15° to 17° Fahr., which implies a relative humidity, if the temperature be 60°, of only 34 per cent. of saturation, which is much too dry for health. In this case the air is always unpleasant, and must be moistened by passing over water before it enters the room, if possible; some heat is thus lost, but not much. Of the various means of heating, water is the best, as it is more under control, and the heat can be carried everywhere. Steam is equally good, if waste steam can be utilized, but if not, it is more expensive. Hot water pipes are of two kinds: pipes in which the water is not heated above 200° Fahr., and which, therefore, are not subjected to great pressure; and pipes in which the water is heated to 300° or 350° Fahr., and which are therefore subjected to great pressure. These pipes (Perkin's patent) are of small internal calibre (about $\frac{1}{4}$ inch), with thick walls made of two pieces of welded iron; the ends of the pipes are joined by an ingeniously contrived screw. In the low-pressure pipes there is a boiler from which the water circulates through the pipes and returns again, outlets being provided at the highest points for the exit of the air. In Perkin's system there is no boiler; one portion of the tube passes through the fire.

Mr. Hood states that 5 feet of a 4-inch pipe will warm 1,000 cubic feet in a public room to 55°. In dwelling-houses for every 1,000 cubic feet 12 feet of 4-inch pipe should be given, and will warm to 65°. In shops, 10 feet, and in workrooms 6 feet per 1,000 cubic feet are sufficient. If Perkin's pipes are used, as the heating power is greater, a less amount does, probably about two-thirds, or a little more.

Steam piping is now also much used, and in some cases is more convenient even than water. The Houses of Parliament are warmed by steam pipes in a chamber under the floor; the radiating surface of the pipes is increased by soldering on to them at intervals a number of zinc or (preferably) small copper plates. If it is wished to lessen the amount of heat, the pipes, where provided with thin plates, are simply covered with a woollen cloth.

The easy storing up and conveyance of heat to any part of the room or house by means of water pipes, the moderate temperature, and the facility of admission of external air at any point by passing the fresh air over coils, or water leaves, make it certain that the plan of warming by hot water will be greatly used in time to come, although the open fire-place may be retained for comfort.

Mr. George has devised a gas stove (called the Calorigen), which appears to be a decided improvement on the common gas stove. Gas is burnt in a small iron box, and the products of combustion are carried to the open air by a tube. Another coiled tube runs up through the box; this communicates below with the outer air, and above opens into the rooms. As the fresh air passes through this tube it is warmed by the heat of the

[1] Die Luftüng und Erwärmung der Kinderstube und des Krankenzimmers, von D. C. Haller, 1860, pp. 29–38.

gas stove. Mr. Eassie speaks very well of this stove, which he has put up in several places. He says he has known one to be persistently capable of registering fifteen degrees above the external temperature during a very severe winter, and that too in a room of over 1,700 cubic feet, with the roof and three sides constructed of glass.[1] A coal calorigen is also made which seems to answer well. Dr. F. T. Bond's Euthermic stove is also a very good contrivance.

A plan which was proposed 130 years ago by Desaguliers is now coming into general use, viz., to have an air-chamber round the back and sides of a radiating grate, and to pass the external air through it into the room. Thus a great economy of heat, and a considerable quantity of gently warmed air, passes into the room. In Captain Galton's grate, and in the plan proposed by Mr. Chadwick for cottages, the lower part of the chimney is also made use of. The advantages of these grates are that they combine a good amount of cheerful open fire, radiant heat, and chimney ventilation, with supplementary warming by hot air, so that more value is obtained from the fuel, and larger spaces can be more effectually warmed. A great number of patents have been taken out for grates of this kind. The air-chamber should not be too small, or the air is unduly heated; the heated surface should be very large; fire-clay sometimes gives a peculiar odor to the air, which iron does not do if the surface of iron be very large and disposed in gills; a combination also of iron and fire-clay is said to be good, and to give no odor. The conduit leading to the air-chamber should be short, and both it and the chamber should be able to be opened and cleaned, as much dust gets in. The room opening of the air-chamber should be so far up that the hot air may not be at once breathed, and there should be no chance of its being at once drawn up the chimney. The action of all stoves of the kind is liable to considerable variation from the action of the wind; and sometimes the current is even reversed and hot air is driven out.

Attention has been lately directed, both in France and America, to the fact of the comparative ease with which gases pass through red hot cast-iron. Mr. Graham showed that iron heated to redness will absorb 4.15 times its volume of carbon monoxide; and the experiments by MM. Deville and Troost, made at the request of General Morin, proved that in a cast-iron stove heated with common coal there passed through the metal in 92 hours 589 C.C. of carbon monoxide,[2] or from .0141 to .132 per cent. of the air which was slowly passed over the hot surface. In America Dr. Derby[3] has directed particular attention to this point, and has adduced very strong reasons for believing that the decidedly injurious effects produced by some of the plans of warming houses, especially by air passing over a cast-iron furnace heated with anthracite is due to an admixture of carbon monoxide. Professor Coulier, of the Val de Grâce,[4] has contended that the amount of carbon monoxide passing through in the experiments of Deville and Troost is really so small, that if mixed with the air of a room which is fairly ventilated, it would be quite innocuous; and he believes (from direct

[1] Sanitary Arrangements for Dwellings, 1874, p. 140.

[2] Comptes Rendus de l'Acad., Jan., 1868. These experiments were first undertaken in consequence of a statement by Dr. Carret, that in the department of Haute-Savoie an epidemic occurred which affected persons only in the houses where iron stoves were, and not porcelain.

[3] Anthracite and Health, by G. Derby, M.D., Professor of Hygiene in Harvard University.

[4] Mem. de Med. Mil., Sept., 1868, p. 250.

experiment) that the headache and oppressive feeling produced by these iron stoves are really owing, as was formerly believed, to the relative dryness of the air. But evidence is adverse to this now. The gas passes with much greater difficulty through wrought-iron, or through stoves lined with fireclay.[1]

A great number of grates and stoves have been proposed, which it is impossible here to notice. In Germany many excellent stoves are now used, which not only economize fuel but warm the outside air, which is admitted round or under them.[2] The medical officer's advice will be sought, first, as to the kind; and second, as to the amount of heat. He will find no difficulty in coming to the conclusion that in most cases both methods (radiation and convection) should be employed; the air warmed by plates or coils of water-pipes being taken fresh from the external air and thereby conducing to ventilation. He will be also called on to state the relative amount of radiant and convected heat, and to determine the heat of the plates, and of the air coming off them, and the degree of humidity of the air. The thermometer, and the dry and wet bulbs, will give him all the information he wants on these points.[3]

[1] Dr. Bond has recommended a coating of silicate as a preventive against the passage of deleterious products through an iron stove.

[2] See a good account in Roth and Lex's work (op. cit., p. 365).

[3] Mr. Chadwick has lately called attention to the old Roman plan of the Hypocaust, where the floor of the room is warmed by pipes, or by carrying smoke-flues under it, and he has contrived some ingenious plans to carry out the idea. There can be no doubt of the great comfort of this plan, although it appears to be expensive. Attention has been called, of late years, to heating on the *whole house* system, and there can be no doubt that this is an excellent plan, if properly carried out and carefully supervised. Drs. Drysdale and Hayward in this country (Health and Comfort in House Building, London, 1872), and Dr. Griscom, of New York, have devised ingenious plans for the purpose. In colder countries, such as Russia, the plan is in general use, but apparently with little or no regard to proper supply of fresh air, or carrying away of foul air.

CHAPTER XII.

EXERCISE.

A PERFECT state of health implies that every organ has its due share of exercise. If this is deficient, nutrition suffers, the organ lessens in size, and eventually more or less degenerates. If it be excessive, nutrition, at first apparently vigorous, becomes at last abnormal, and in many cases, a degeneration occurs which is as complete as that which follows the disuse of an organ. Every organ has its special stimulus which excites its action, and if this stimulus is perfectly normal as to quality and quantity, perfect health is necessarily the result.

But the term exercise is usually employed in a narrower sense, and expresses merely the action of the voluntary muscles. This action, though not absolutely essential to the exercise of other organs, is yet highly important, and indeed, in the long run, is really necessary; the heart especially is evidently affected by the action of the voluntary muscles, and this may be said of all organs, with the exception perhaps of the brain. Not only the circulation of the blood, but its formation and its destruction, are profoundly influenced by the movement of the voluntary muscles. Without this muscular movement health must inevitably be lost, and it becomes therefore important to determine the effects of exercise, and the amount which should be taken.

SECTION I.

THE EFFECTS OF EXERCISE.

(*a*) *On the Lungs—Elimination of Carbon.*—The most important effect of muscular exercise is produced on the lungs. The pulmonary circulation is greatly hurried, and the quantity of air inspired, and of carbon dioxide expired, is marvellously increased. Dr. Edward Smith investigated the first point carefully, and the following table shows his main results. Taking the lying position as unity, the quantity of air inspired was found to be as follows:—

Lying position	1.0	Walking and carrying 63 lb,	3.84
Sitting	1.18	" " 118 lb,	4.75
Standing	1.33	" 4 miles per hour	5.0
Singing	1.26	" 6 " "	7.0
Walking 1 mile per hour,	1.9	Riding and trotting	4.05
" 2 miles "	2.76	Swimming	4.33
" 3 " "	3.23	Treadmill	5.5
" and carrying 34 lb,	3.5		

The great increase of air inspired is more clearly seen when it is put in this way: under ordinary circumstances, a man draws in 480 cubic inches

per minute; if he walks four miles an hour he draws in (480 × 5 =) 2,400 cubic inches; if six miles an hour (480 × 7 =) 3,260 cubic inches. Simultaneously, the amount of carbon dioxide in the expired air is increased (Scharling and many others).

The most reliable observations in this direction are those made by E. Smith, Hirn,[1] Speck,[2] and Pettenkofer and Voit.[3] As there is no doubt that the peculiar means of investigation render the experiments of the last-named authors as accurate as possible in the present state of science, they are given briefly in the following table.[4]

Absorption and Elimination in Rest and Exercise.

	Absorption of Oxygen in Grammes.	Elimination in Grams of—		
		Carbon Dioxide.	Water.	Urea.
Rest-day	708.9	911.5	828.0	37.2
Work-day	954.5	1284.2	2042.1	37
Excess on work-day (with exception of urea)	245.6	372.7	1214.1	−0.2

In other words, during the work-day, 3,804 grains or 8.69 ounces of oxygen were absorbed in excess of the rest-day, and 5,750 grains or 13 ounces in excess of carbon dioxide were evolved. Expressing this as carbon, an excess of 1,568 grains or 3.58 ounces were eliminated in the work-day. There was an excess of oxidation of carbon equal to 34.6 per cent., and it must be remembered that the so-called "work-day" included a period of rest; the work was done only during the working hours, and was not excessive.

It will be observed from these experiments that a large amount of water was eliminated during exercise, while the urea was slightly lessened.

It seems certain that the great formation of carbon dioxide takes place in the muscles;[5] it is rapidly carried off from them, and if it is not so, it would seem highly probable that their strong action becomes impossible. At any rate, if the pulmonary circulation and the elimination of carbon dioxide are in any way impeded, the power of continuing the exertion rapidly lessens. The watery vapor exhaled from the lungs is also largely increased during exertion.

Muscular exercise is then clearly necessary for a sufficient elimination of carbon from the body, and it is plain that, in a state of prolonged rest, either the carboniferous food must be lessened or carbon will accumulate.

Excessive and badly arranged exertion may lead to congestion of the lungs and even hæmoptysis. Deficient exercise, on the other hand, is one

[1] Ludwig's Phys., 2d edit., Band i., p. 743.

[2] Archiv des Vereins für wiss. Heilk., Band vi., pp. 285 and 289.

[3] Zeitsch. für Biologie, Bands ii. and iii., and Ranke's Phys. des Menschen, p. 551.

[4] The numbers given by Hirn and Speck are very accordant; they will be found quoted in the 2d edition of this work, if it is wished to refer to them.

[5] See the observations of Valentin and others, and especially the experiments of Sczelkow (Henle's Zeitschrift, 1863, Band xvii., p. 106). The amount of CO_2 passing off from contracting muscles was indeed so great, and so much in excess of the O passing to them, that it was conjectured that carbonic acid must have been formed during contraction from substances rich in oxygen (such as formic acid), or that oxygen must have been obtained otherwise than from inspiration.

of the causes which produce those nutritional alterations in the lung which we class as tuberculous.

Certain rules flow from these facts. During exercise the action of the lungs must be perfectly free; not the least impediment must be offered to the freest play of the chest and the action of the respiratory muscles. The dress and accoutrements of the soldier should be planned in reference to this fact, as there is no man who is called on to make, at certain times, greater exertion. And yet, till a very recent date, the modern armies of Europe were dressed and accoutred in a fashion which took from the soldier, in a great degree, that power of exertion for which, and for which alone, he is selected and trained.

The action of the lungs should be watched when men are being trained for exertion; as soon as the respirations become laborious, and especially if there be sighing, the lungs are becoming too congested, and rest is necessary.

A second point is, that the great increase of carbon excreted demands an increase of carbon to be given in the food. There seems a general accordance, among physiologists, that this is best given in the form of fat, and not of starch, and this is confirmed by the instinctive appetite of a man taking exertion, and not restrained in the choice of food.

A third rule is, that as spirits lessen the excretion of pulmonary carbon dioxide, they are hurtful during exercise; and it is perhaps for this reason, as well as from their deadening action on the nerves of volition, that those who take spirits are incapable of great exertion. This is now well understood by trainers, who allow no spirits, and but little wine or beer. It is a curious fact, stated by Artmann, that if men undergoing exertion take spirits, they take less fat. Possibly in reality they lessen the amount of exertion, and therefore require less fat. Water alone is the best fluid to train on.

A fourth rule is, that as the excretion of carbon dioxide (and perhaps of pulmonary organic matter) is so much increased, a much larger amount of pure air is necessary; and in every covered building (as gymnasia, riding-schools, etc.) where exercise is taken, the ventilation must be carried to the greatest possible extent, so soon does the air become vitiated.

(*b*) *On the Heart and Vessels.*—The action of the heart rapidly increases in force and frequency, and the flow of blood through all parts of the body, including the heart itself, is augmented. The amount of increase is usually from ten to thirty beats, but occasionally much more. After exercise, the heart's action falls below its normal amount; and if the exercise has been exceedingly prolonged and severe, may fall as low as fifty or forty per minute, and become intermittent. During exertion, when the heart is not oppressed, its beats, though rapid and forcible, are regular and equable; but when it becomes embarrassed, the pulse becomes very quick, small, and then unequal, and even at last irregular. When men have gone through a good deal of exertion, and then are called upon to make a sudden effort, the pulse may become very small and quick (160–170), but still retain its equability. There seems no harm in this, but such exertion cannot be long continued.

The ascension of heights greatly tries a fatigued heart. The accommodation of the heart to great exertion is probably connected with the easy flow of blood through its own structure.

Excessive exercise leads to affection of the heart; rupture (in some few cases), palpitation, hypertrophy in a good many cases, and more rarely valvular disease. These may be avoided by careful training, and a due

proportion of rest. Injuries to vessels may also result from too sudden or prolonged exertion. The sphygmographic observations of Dr. Fraser [1] on the pulses of men after rowing, show how much the pressure is increased.

Deficient exercise leads to weakening of the heart's action, and probably to dilatation and fatty degeneration.

In commencing an unaccustomed exercise, the heart must be closely watched; excessive rapidity (120–140), inequality, and then irregularity, will point out that rest, and then more gradual exercise, are necessary, in order that the heart may be accustomed to the work.

(*c*) *On the Skin.*—The skin becomes red from turgescence of the vessels, and perspiration is increased; water, chloride of sodium, and acids (probably in part fatty) pass off in great abundance. Some nitrogen passes off in a soluble form (urea?), but the amount is extremely small.[2] No gaseous nitrogen is given off in healthy men from the skin.

The amount of fluid passing off is not certain, but is very great. Speck's experiments show that it is at least doubled under ordinary conditions. Pettenkofer and Voit's experiments show even a larger increase. The usual ratio of the urine to the lung and skin excreta is reversed. Instead of being 1 to 0.5 or 0.8, it becomes 1 to 1.7, or 2, or even 2.5. This evaporation reduces and regulates the heat of the body, which would otherwise soon become excessive; so that, as long ago pointed out by Dr. John Davy, the body temperature rises little above the ordinary temperature. No amount of external cold seems to be able to hinder the passage of fluid, though it may partly check the rapidity of evaporation. If anything check evaporation, the body heat increases, and soon languor comes on and exertion becomes difficult.

During exertion there is little danger of chill under almost any circumstances; but when exertion is over, there is then great danger, because the heat of the body rapidly declines, and falls below the natural amount, and yet evaporation from the skin, which still more reduces the heat, continues.

The rules to be drawn from these facts are—that the skin should be kept extremely clean; during the period of exertion, it may be thinly clothed, but immediately afterward, or in the intervals of exertion, it should be covered sufficiently well to prevent the least feeling of coolness of the surface. Flannel is best for this purpose.

(*d*) *On the Voluntary Muscles.*—The muscles grow, become harder, and respond more readily to volition. Their growth, however, has a limit; and a single muscle, or group of muscles, if exercised to too great an extent, will, after growing to a great size, commence to waste. But this seems not to be the case when all the muscles of the body are exercised, probably because no muscle can then be over-exercised. It seems to be a fact, however, that prolonged exertion, without sufficient rest, damages to a certain extent the nutrition of the muscles, and they become soft.

The rules to be drawn from these facts are, that all muscles, and not single groups, should be brought into play, and that periods of exercise must be alternated, especially in early training, with long intervals of rest.

(*e*) *On the Nervous System.*—The effect of exercise on the mind is not clear. It has been supposed that intellect is less active in men who take excessive exercise, owing to the greater expenditure of nervous force in

[1] Journal of Physiology, November, 1868.

[2] See On the Excretion of Nitrogen by the Skin, by J. Byrne Power, L.C.P.I., Proceedings of the Royal Society, 1882, vol. xxxiii., p. 354.

that direction. But there is no doubt that great bodily is quite consistent with extreme mental activity; and, indeed, considering that perfect nutrition is not possible except with bodily activity, we should infer that sufficient exercise would be necessary for the perfect performance of mental work. Doubtless, exercise may be pushed to such an extreme as to leave no time for mental cultivation; and this is perhaps the explanation of the proverbial stupidity of the athletæ. Deficient exercise causes a heightened sensitiveness of the nervous system, a sort of morbid excitability, and a greater susceptibility to the action of external agencies.

(*f*) *On the Digestive System.*—The appetite largely increases with exercise, especially for meat and fat, but in a less degree, it would appear, for the carbohydrates. Digestion is more perfect, and absorption is more rapid. The circulation through the liver increases, and the abdominal circulation is carried on with more vigor. Food must be increased, especially nitrogenous substances, fats, and salts, and of these especially the phosphates and the chlorides.[1] The effects of exercise on digestion are greatly increased if it be taken in the free air, and it is then a most valuable remedy for some forms of dyspepsia.[2] Conversely, deficient exercise lessens both appetite and digestive power.

(*g*) *On the Generative Organs.*—It has been supposed that puberty is delayed by physical exertion, but perhaps the other circumstances have not been allowed full weight. Yet, it would appear that very strong exercise lessens sexual desire, possibly because nervous energy is turned in a special direction.

(*h*) *On the Kidneys.*—The water of the urine and the chloride of sodium often lessen in consequence of the increased passage from the skin. The urea is not much changed. The uric acid increases after great exertion; so also apparently the pigment; the phosphoric acid is not augmented;[3] the sulphuric acid is moderately increased; the free carbonic acid of the urine is increased; the chlorides are lessened on account of the outflow by the skin; the exact amount of the bases has not been determined, but a greater excess of soda and potash is eliminated than of lime or magnesia; nothing certain is known as to hippuric acid, sugar, or other substances.[4]

[1] It is yet uncertain what kind of diet should be allowed during long marches in the tropics. Dr. Kirk states that in South Africa (10° to 17° S.L.), during Dr. Livingstone's second expedition, a large quantity (2 lb) of animal food was found to be essential; this was preferred, though any quantity of millets and leguminosæ could have been procured. Fat was taken in large quantities It was found, also, that boiled was better than roast meat, because the men could eat more of it. No bad effect whatever was traceable to the use of this great amount of meat, even to the intensest heat.

[2] James Blake, Pacific Medical and Surgical Journal, 1860.

[3] Dr. Parkes' experiments.

[4] In the careful observations made by Dr. Pavy on Weston, the pedestrian (Lancet, December, 1876), the following changes were found; taking the amount excreted during rest as 1:—

Constituents.	Rest.	Walking.
Urea	1	1.743
Uric acid	1	1.287
Chlorine	1	.478
Sulphuric acid	1	1.520
Phosphoric acid	1	1.985
Soda	1	.822
Potash	1	1.424
Lime	1	1.559
Magnesia	1	.989

All the constituents thus appear to be increased, except the chlorine and the soda,

(*i*) *On the Bowels.*—The effect of exercise is to lessen the amount, partly, probably from lessened passage of water into the intestines. The nitrogen does not appear to be much altered.[1]

(*k*) *On the Elimination of Nitrogen.*—A great number of experiments have been made in the amount of nitrogen passing off by the kidneys during exercise.[2] The amount of urea has been usually determined, and the nitrogen has been calculated from this; Meissner has determined the amount of the creatin, and the creatinine;[3] while Fick and Wislicenus have compared the total nitrogen (by soda lime in the manner of Voit) as well as the ureal nitrogen, and Dr. Parkes repeated their experiments.[4] The experiments have been usually carried on by determining the nitrogenous excretion in twenty-four hours with and without exercise; but in some, the period during which work was actually performed was compared with previous and subsequent equal rest periods. Some experiments were performed on men who took no nitrogen as food; others were on men on a constant diet, so that the variation produced by the altering ingress of nitrogen was avoided as far as possible.

In this place it is impossible to give an account of these long researches, and therefore only a short summary can be given. (1) When a period of exercise is compared after an interval with one of rest (the diet being without nitrogen or with uniform nitrogen), the elimination of nitrogen by the kidneys is decidedly not increased in the exercise period. The experiments on this point are now so numerous that it may be stated without doubt. It is possible that the elimination may even be less during the exercise than during the work period. This would appear in part from some of Ranke's, and Fick and Wislicenus' experiments; from Noyes', as far as regards the urea; and from Meissner's, as far as the creatin (or creatinine) is concerned; while Dr. Parkes found a decrease, which was not inconsiderable, both in the total nitrogen and in the, urea. Additional observations are, however, much wanted on this point.

(2) When a day of rest is compared with a day of work (*i.e.*, a day with some hours of work and some hours of rest), the amount of nitrogen is almost or quite the same on the two days; if anything there is a slight increase in the nitrogen on the rest day. In a day of part exercise and part rest, it is quite possible that there may be compensatory action, one part balancing the other, so as to leave the total excretion little changed.

(3) When a period of great exercise is immediately followed by an equal period of rest, the nitrogenous elimination is increased in the latter. Meissner's observations show that this is in part owing to increased discharge of creatin and creatinine; Parkes' observations also show an increase of non-ureal nitrogen. But the urea is also slightly increased in this period.

(4) When two days of complete rest are immediately followed by days

which are notably diminished, especially the chlorine; the magnesia is also diminished, but in a much less degree. In these experiments, however, the diet was not uniform, and the exercise was excessive.

[1] Proceedings of the Royal Society, No. 94, 1867, p. 52.

[2] For a statement of these experiments up to 1860, see Dr. Parkes' work On the Composition of the Urine, 1860, p. 85. Since this time the chief experiments have been by Voit, Pettenkofer, J. Ranke, E. Smith, Haughton, Fick and Wislicenus, Byasson, Noyes, Meissner, Pavy, Parkes, and others. At present the subject is being investigated by a Committee of the British Association.

[3] Henle's Zeitschrift at. Med., Band xxxii., p. 283.

[4] Proceedings of the Royal Society, No. 89 (1867), and No. 94 (1867).

of common exercise, the nitrogenous elimination diminishes during the first day of exercise (Parkes).

On the whole, if the facts have been stated correctly, the effect of exercise is certainly to influence the elimination of nitrogen by the kidneys, but within narrow limits, and the time of increase is in the period of rest succeeding the exercise; while during the exercise period the evidence, though not certain, points rather to a lessening of the elimination of nitrogen.

It would appear from these facts that well-fed persons taking exercise would require a little more nitrogen in the food, and it is certain, as a matter of experience, that persons undergoing laborious work do take more nitrogenous food. This is the case also with animals. The possible reason of this will appear presently.

(*l*) *On the Temperature of the Body.*—As already stated, the temperature of the body, as long as the skin acts, rises little. Dr. Clifford-Allbutt,[1] from observations made on himself when climbing the Alps,[2] found his temperature fairly uniform; the most usual effect was a slight rise, compensated by an earlier setting in of the evening fall. On two occasions he noticed two curious depressions, amounting to no less than 4.5° Fahr.; he believes these were due to want of food, and not to exercise *per se*. In experiments on soldiers when marching, Dr. Parkes found no difference in temperature; or if there was a very slight rise, it was subsequently compensated for by an equal fall, so that the mean daily temperature remained the same.[3] A decided rise in temperature during marching would then show lessening of skin evaporation, and may possibly be an important indication of impending sunstroke.

Changes in the Muscles.—The discussion on this head involves so many obscure physiological points, that it would be out of place to pursue it here to any length. The chief changes during action appear to be these:—There is a considerable increase in temperature (Helmholtz) which, up to a certain point, is proportioned to the amount of work. It is also proportioned to the kind, being less when the muscle is allowed to shorten than if prevented from shortening (Heidenhain); the neutral or alkaline reaction of the tranquil muscle becomes acid from para-lactic acid and acid potassium phosphate; the venous blood passing from the muscles becomes much darker in color, is much less rich in oxygen, and contains much more carbonic acid (Sczelkow); the extractive matters soluble in water lessen, those soluble in alcohol increase (Helmholtz, in frogs); the amount of water increases (in tetanus, J. Ranke), and the blood is consequently poorer in water; the amount of albumen in tetanus is less according to Ranke, but Kühne has pointed out that the numbers do not justify this inference.[4] Baron J. von Liebig stated that the creatin is increased (but this was an inference from old observations on the *extractum carnis* of hunted animals, and required confirmation). Sarokin has stated the same fact in respect of the frog. The electro-motor currents show a decided diminution during contraction.

[1] Alpine Journal, May, 1871.

[2] In the experiments made by Dr. Calberla (Archiv der Heilkunde, 1875, p. 276) and his two guides, during their ascents of Monte Rosa and the Matterhorn, in August, 1874, no depressions were found as have been recorded by other observers. In none of the three persons did the temperature ever fall below 36.4° C. (=97.5° F.), or rise above 37.8° C. (=100° F.). Dr. Thomas, of Leipsic, in ascents in Savoy and Dauphiné (3,500 and 3,750 metres), could also find no lowering of temperature.

[3] Proceedings of the Royal Society, No. 127 and No. 136.

[4] Lehrb. der Phys. Chem., 1868, p. 323.

That great molecular changes go on in the contracting muscles is certain, but their exact nature is not clear; according to Ludimar Hermann,[1] there is a jelly-like separation and coagulation of the myosin, and then a resumption of its prior form, so that there is a continual splitting of the muscular structure into a myosin coagulum, carbon dioxide, and a free acid, and this constitutes the main molecular movement. But no direct evidence has been given of this.

The increased heat, the great amount of carbon dioxide, and the disappearance of oxygen, combined with the respiratory phenomena already noted, all seem to show that an active oxidation goes on, and it is very probable that this is the source of the muscular action. The oxidation may be conceived to take place in two ways—either during rest oxygen is absorbed and stored up in the muscles and gradually acts there, producing a substance which, when the muscle contracts, splits up into lactic acid, carbon dioxide, etc.; or, on the other hand, during the contraction an increased absorption of oxygen goes on in the blood and acts upon the muscles, or on the substances in the blood circulating through the muscles.[2] The first view is strengthened by some of Pettenkofer and Voit's experiments, which show that during rest a certain amount of storage of oxygen goes on, which no doubt in part occurs in the muscles themselves. Indeed, it has been inferred that it is this stored up oxygen, and not that breathed in at the time, which is used in muscular action. The increased oxidation gives us a reason why the nitrogenous food must be increased during periods of great exertion. An increase in the supply of oxygen is a necessity for increased muscular action; but Pettenkofer and Voit's observations have shown that the absorption of oxygen is dependent on the amount and action of the nitrogenous structures of the body, so that, as a matter of course, if more oxygen is required for increased muscular work, more nitrogenous food is necessary. But apart from this, although experiments on the amount of nitrogenous elimination show no very great change on the whole, there is no doubt that, with constant regular exercise, a muscle enlarges, becomes thicker, heavier, contains more solid matter, and in fact has gained in nitrogen. This process may be slow, but it is certain; and the nitrogen must either be supplied by increased food, or be taken from other parts.[3]

So that, although we do not know the exact changes going on in the muscles, it is certain that regular exercise produces in them an addition of nitrogenous tissue.

Whether this addition occurs, as usually believed, in the period of rest succeeding action, when in some unexplained way the destruction, which it is presumed has taken place, is not only repaired, but is exceeded (a process difficult to understand), or whether the addition of nitrogen is actually made during the action of the muscle,[4] must be left undecided for the present.

[1] Unters. über den Stoffwechsel der Muskeln, von Dr. L. Hermann; Weitere Untersuch. zur phys. der Muskeln, von Dr. L. Hermann, 1867.

[2] Heaton (Quarterly Journal of Science, 1868) has given strong reasons for believing that the oxidation goes on in the blood.

[3] The way in which a vigorously acting part will rob the body of nitrogen, and thus in some cases cause death, is seen in many cases of disease. A rapidly growing cancer of the liver, for example, takes so much nitrogen as well as fat that it actually starves the rest of the body, and both voluntary muscles and heart waste. This is the case, though it is less marked, with growing tumors of other parts, and with great discharges. Powerful muscular action, if the food is not increased, evidently acts in something the same way; the health is greatly affected, and the heart especially fails.

[4] Proceedings of the Royal Society, No. 94, 1867.

The substances which are thus oxidized in the muscle, or in the blood circulating through it, and from which the energy manifested, as heat or muscular movement, is believed to be derived, may probably be of different kinds. Under ordinary circumstances, the experiments and calculations of Fick and Wislicenus, and others, and the arguments of Traube, seem sufficient to show that the non-nitrogenous substances, and perhaps especially the fats, furnish the chief substances acted upon. But it is probable that the nitrogenous substances also furnish a contingent of energy.[1] The exact mode in which the energy thus liberated by oxidation is made to assume the form of mechanical motion is quite obscure.

The Exhaustion of Muscles.

There seems little doubt that the exhaustion of muscles is chiefly owing to two causes—first, and principally, to the accumulation in them of the products of their own action (especially para-lactic acid); and, secondly, from the exhaustion of the supply of oxygen. Hence rest is necessary, in order that the blood may neutralize and carry away the products of action, so that the muscle may recover its neutrality and its normal electrical currents, and may again acquire oxygen in sufficient quantity for the next contraction. In the case of all muscles these intervals of action and of exhaustion take place, in part even in the period which is called exercise, but the rest is not sufficient entirely to restore it. In the case of the heart, the rest between the contractions (about two-thirds of the time), is sufficient to allow the muscle to recover itself perfectly.

The body after exertion absorbs and retains water eagerly; the water, though taken in large quantities, does not pass off as rapidly as usual by the kidneys or the skin, and instead of causing an augmented metamorphosis, as it does in a state of rest, it produces no effect whatever. So completely is it retained, that although the skin has ceased to perspire, the urine does not increase in quantity for several hours. The quantity of water taken is sometimes so great as not only to cover the loss of weight caused by the exercise, but even to increase the weight of the body.

We can be certain, then, of the absolute necessity of water during and after exercise, and the old rule of the trainer, who lessened the quantity of water to the lowest point which could be borne, must be wrong. In fact, it is now being abandoned by the best trainers, who allow a liberal allowance of fluid. The error probably arose in this way: if, during great exertion, water is denied, at the end of the time an enormous quantity is often drunk, more, in fact, than is necessary, in order to still the overpowering thirst. The sweating which the trainer had so sedulously encouraged is thus at once compensated, and, in his view, all has to be done over again. All this seems to be a misapprehension of the facts. The body must have water, and the proper plan is to let it pass in in small quantities

[1] Pavy shows, in his observations on Weston and Perkins, that the excess of nitrogen eliminated during the walking period, over the period of rest, was equivalent to about 542 foot-tons per man per diem. The total average daily work done, he states at 1,264 foot-tons, but this is an under-estimate, as the velocity was apparently greater than that of average walking, the co-efficient of which ($\frac{1}{210}$) he assumes as the proportion of resistance. *N.B.*—One grain of nitrogen eliminated, represents an amount of albuminate expended, capable of yielding about 2.4 foot-tons of potential energy. Although some of the excess of nitrogen eliminated during exercise, as noted above, may have been due to disintegration of muscle, part of it was due (undoubtedly) to changes in other tissues, but a considerable amount is due to direct oxidation of albuminous food.

and frequently; not to deny it for hours, and then to allow it to pass in in a deluge. The plan of giving it in small quantities frequently, does away with two dangers, viz., the rapid passage of a large quantity of cold water into the stomach and blood, and the taking more than is necessary.[1]

In the French army, on the march, the men are directed not to drink; but if very thirsty, to hold water in the mouth, or to carry a bullet in the mouth. It is singular, in that nation of practical soldiers, to find such an order. Soldiers ought to be abundantly supplied with water, and taught to take small quantities, when they begin to feel thirsty or fatigued. If they are hot, the cold water may be held in the mouth a minute or two before swallowing as a precaution; though there seems to be no evidence of any ill effects from drinking a moderate quantity of cold water, even during the greatest heat of the body.[2]

General Effect of Exercise on the Body, as judged of by the Preceding Facts.—The main effect of exercise is to increase oxidation of carbon, and perhaps also of hydrogen; it also eliminates water from the body, and this action continues, as seen from Pettenkofer and Voit's experiments, for some time; after exercise, the body is therefore poorer in water, especially the blood; it increases the rapidity of circulation everywhere, as well as the pressure on the vessels, and therefore it causes in all organs a more rapid outflow of plasma and absorption,—in other words, a quicker renewal. In this way also it removes the products of their action, which accumulate in organs; and restores the power of action to the various parts of the body. It increases the outflow of warmth from the body by increasing perspiration. It therefore strengthens all parts. It must be combined with increased supply both of nitrogen and carbon (the latter possibly in the form of fat), otherwise the absorption of oxygen, the molecular changes in the nitrogenous tissues, and the elimination of carbon, will be checked. There must be also an increased supply of salts, certainly of chloride of sodium; probably of potassium phosphate and chloride. There must be proper intervals of rest, or the store of oxygen, and of the material in the muscles which is to be metamorphosed during contraction, cannot take place. The integrity and perfect freedom of action both of the lungs and heart are essential, otherwise neither absorption of oxygen nor elimination of carbon can go on, nor can the necessary increased supply of blood be given to the acting muscles without injury.

In all these points, the inferences deducible from the physiological inquiries seem to be quite in harmony with the teachings of experience.

[1] It is but right to say that many travellers of great experience have expressed great fear of water under exertion. Some of them have most strongly urged that "water be avoided like poison," and have stated that a large quantity of butter is the best preventive of thirst. At any rate, the butter may be excellent, but a little water is a necessity.

[2] Horses also used to be, and by some are now, deprived or stinted of water during exercise. But in India, the native horsemen give their horses drink as often as they can; and Dr. Nicholson says this is the case with the Cape horses; even when the horses are sweating profusely, the men will ride them into a river, bathe their sides, and allow them to drink.

SECTION II.

AMOUNT OF EXERCISE WHICH SHOULD BE TAKEN.

It would be extremely important to determine, if possible, the exact amount of exercise which a healthy adult, man or woman, should take. Every one knows that great errors are committed, chiefly on the side of defective exercise. It is not, however, easy to fix the amount even for an average man, much less to give any rule which shall apply to all the divers conditions of health and strength. But it is certain that muscular work is not only a necessity for health of body, but for mind also; at least it has seemed that diminution in the size of the body from deficient muscular work seems to lead in two or three generations to degenerate mental formation.

The external work which can be done by a man daily has been estimated at $\frac{1}{7}$th of the work of the horse; but if the work of a horse is considered to be equal to the 1-horse power of a steam engine (viz., 33,000 lb raised 1 foot high per minute, or 8,839 tons raised 1 foot high in ten hours), this must be an over-estimate, as $\frac{1}{7}$th of this would be 1,263 tons raised 1 foot in a day's work of ten hours.[1] The hardest day's work of

[1] In some works on physiology a man's work of eight hours has been put as high as 316,800 kilogrammemetres, or 1,020 tons lifted a foot; but this is far too much.

In this country the amount of work done is generally estimated as so many lb or tons lifted one foot. In France it is expressed as so many kilogrammes lifted 1 metre. Kilogrammemetres are converted into foot-pounds by multiplying by 7.233. To bring at once into tons lifted a foot, multiply kilogrammemetres by .003229. The following table may be useful, as expressing the amount of work done. It is taken from Dr. Haughton's work (A New Theory of Muscular Action). The numbers are a little different from those given by Coulomb, as they were recalculated by Dr. Haughton in 1863.

LABORING FORCE OF MAN.

Kind of Work.	Amount of Work.	Authority.
Pile driving	312 tons lifted 1 foot.	Coulomb.
Pile driving	352 " "	Lamande.
Turning a winch	374 " "	Coulomb.
Porters carrying goods and returning unladen	325 " "	"
Pedlers always loaded	303 " "	"
Porters carrying wood up a stair and returning unloaded	381 " "	"
Paviors at work	352 " "	Haughton.
Military prisoners at shot drill (3 hours), and oakum picking and drill	310 " "	"
Shot drill alone (3 hours)	160.7 " "	"

It may be interesting to give some examples of work done in India by natives, which have been noted by Dr. de Chaumont:—

A Leptcha hill-coolie will go from Punkabarree to Darjeeling (30 miles, and an ascent of 5,500 feet), in three days, carrying 80 lb weight; the weight is carried on a frame supported on the loins and sacrum, and aided by a band passed round the forehead.

Work per diem, 500 tons lifted 1 foot.

Eight palanquin bearers carried an officer weighing 180 lb, and palanquin weighing 250 lb, 25 miles in Lower Bengal. Assuming each man weighed 150 lb, the work was 600 tons lifted a foot.

twelve hours noted by Dr. Parkes was in the case of a workman in a copper rolling-mill. He stated that he occasionally raised a weight of 90 lb to a height of 18 inches, 12,000 times a day. Supposing this to be correct, he would raise 723 tons 1 foot high. But this much overpasses the usual amount. The same man's ordinary day's work, which he considered extremely hard, was raising a weight of 124 lb 16 inches, 5,000 or 6,000 times in a day. Adopting the larger number, this would make his work equivalent to 442.8 tons lifted a foot; and this was a hard day's work for a powerful man. Some of the puddlers in the iron country, and the glass-blowers, probably work harder than this; but there are no calculations recorded. From the statement of a pedler, his ordinary day's work was to carry 28 lb twenty miles daily. The weight is balanced over the shoulder —14 lb behind and 14 lb in front. The work is equal to 419.5 tons lifted 1 foot. It would, therefore, seem certain that an amount of work equal to 500 tons lifted a foot is an extremely hard day's work, which perhaps few men could continue to do. 400 tons lifted a foot is a hard day's work, and 300 tons lifted a foot is an average day's work for a healthy, strong adult.

The external work is thus 300 to 500 tons on an average; the internal work of the heart, muscles of respiration, digestion, etc., has been variously estimated; the estimates for the heart alone vary from 122 to 277 tons lifted a foot. The former is that given by Haughton, who estimates the respiratory movements as about 11 tons lifted a foot in twenty-four hours. Adopting a mean number of 260 tons for all the internal mechanical work, and the external work of a mechanic being 300 to 500 tons, this will amount to from $\frac{1}{7}$th to $\frac{1}{5}$th of all the force obtainable from the food.

The exertion which the infantry soldier is called upon to undergo is chiefly drill and carrying weights on a level, or over an uneven surface.

The Reverend Professor Haughton, M.D., who is so well known for his important contributions to physiology and medicine, has shown that walking on a level surface at the rate of about 3 miles an hour is equivalent to raising $\frac{1}{20}$th part of the weight of the body through the distance walked; an easy calculation changes this into the weight raised 1 foot. When ascending a height, a man of course raises his whole weight through the height ascended.

Using this formula,[1] and assuming a man to weigh 150 lb with his clothes, we get the following table:—

Kind of Exercise.	Work done in Tons lifted one foot.
Walking 1 mile	17.67
" 2 miles	35.34
" 10 "	176.7
" 20 "	353.4
" 1 mile and carrying 60 lb	24.75
" 2 miles " "	24.75
" 10 " " "	247.5
" 20 " " "	495

It is thus seen that a march of 10 miles, with a weight of 60 lb (which

[1] The formula is $\frac{(W + W') \times D}{20 \times 2,240}$; where W is the weight of the person, W' the weight carried; D the distance walked in feet; 20 the co-efficient of traction; and 2,240 the number of pounds in a ton. The result is the number of tons raised 1 foot. To get the distance in feet, multiply 5,280 by the number of miles walked.

is nearly the weight a soldier carries when in marching order, but without blankets and rations), is a moderate day's work. A 20 miles' march, with 60 lb weight, is a very hard day's work. As a continued laboring effort Dr. Haughton believes that walking 20 miles a day, without a load (Sunday being rest), is good work (353 tons lifted a foot); so that the load of 60 lb additional would make the work too hard for a continuance.[1]

It must, however, be remembered, that it is understood that the walking is on level ground, and is done in the easiest manner to the person, and that the weights which are carried are properly disposed. The labor is greatly increased if the walk is irksome, and the weights are not well adjusted. And this is the case with the soldier. In marching his attitude is stiff; he observes a certain time and distance in each step; he has none of those shorter and longer steps, and slower and more rapid motion, which assist the ordinary pedestrian. It may be questioned, indeed, whether the formula does not under-estimate the amount of work actually done by the soldier. The work becomes heavier, too, *i.e.*, more exhausting, if it is done in a shorter time; or, in other words, velocity is gained at the expense of carrying power.[2] The velocity, in fact, *i.e.*, the rate at which

[1] I calculated the work done by the sledge-parties in the Arctic Expedition of 1875–76, and found that the Northern party (Markham's), did a mean of 574 foot-tons per man per diem, with a maximum of 859; the Western party (Aldrich's) did a mean of 443, and a maximum of over 600. Even this large amount was considered an under-estimate by the Commanders. (See Report of Committee on Outbreak of Scurvy (Blue Book), App. 24, p. 365).—[F. de C.]

[2] Dr. Haughton (Principles of Animal Mechanics, 2d ed., pp. 56 and 57) has determined, from the calculation of the MM. Weber, the co-efficient of resistance for three velocities, as follows:—

Miles per hour.	Co-efficient of Resistance.
1.818	$\frac{1}{25.27}$
4.353	$\frac{1}{15.70}$
10.577	$\frac{1}{7.51}$

Interpolating between these numbers we can obtain the co-efficients at other velocities. The following table shows the co-efficients, the distance in miles that would equal 300 foot-tons for a man of 150 lb, and the time in hours and minutes that would be required without rest:—

Velocity in Miles per hour.	Co-efficient of Resistance.	Distance for Men of 160 lb, to equal 300 foot-tons.	Time required in Hours and Minutes. H.	M.
1	$\frac{1}{28.08}$	30.2	30	12
2	$\frac{1}{26.74}$	21.2	10	36
3	$\frac{1}{20.59}$	16.3	5	24
4	$\frac{1}{16.74}$	13.3	3	18
5	$\frac{1}{14.10}$	11.2	2	36
6	$\frac{1}{12.18}$	9.6	1	36
7	$\frac{1}{10.72}$	8.5	1	12
8	$\frac{1}{9.60}$	7.6	0	57
9	$\frac{1}{8.63}$	6.9	0	46
10	$\frac{1}{7.89}$	6.3	0	38

The co-efficient $\frac{1}{9.6}$ corresponds very nearly to 3.1 miles an hour, and this appears to be the rate at which the greatest amount of work can be done at the least expenditure of energy. (See Table XVIII., p. 186, Lectures on State Medicine, by F. de Chaumont.) As regards velocity, Dr. Haughton states the "Law of Fatigue" as follows:—"When the same muscle (or group of muscles) is kept in constant action till fatigue sets in, the total work done, multiplied by the rate of work, is constant." The "Law of Refreshment" depends on the rate at which arterial blood is supplied to the muscles, and the "Co-efficient of Refreshment" is the work restored to the muscles in foot-pounds per ounce of muscle per second; for voluntary muscle it is on an average 0.1309, and for the heart 0.2376, or exactly equal to the work of the heart, which never tires.—[F. de C.].

work is done, is an important element in the question, in consequence of the strain thrown on the heart and lungs. The Oxford boat races—rowing at racing speed (= 1 mile in 7 minutes) in an Oxford eight-oar, or 18.56 foot-tons in 7 minutes,[1] is not apparently very hard work, but it is very severe for the time, as its effect is great on the circulatory system.

Looking at all these results, and considering that the most healthy life is that of a man engaged in manual labor in the free air, and that the daily work will probably average from 250 to 350 tons lifted 1 foot, we can perhaps say, as an approximation, that every healthy man ought, if possible, to take a daily amount of exercise in some way, which shall not be less than 150 tons lifted 1 foot. This amount is equivalent to a walk of about 9 miles; but then, as there is much exertion taken in ordinary business of life, this amount may be in many cases reduced. It is not possible to lay down rules to meet all cases; but probably every man with the above facts before him could fix the amount necessary for himself with tolerable accuracy.

In the case of the soldier, if he were allowed to march easily, and if the weights were not oppressively arranged, he ought to do easily 12 miles daily for a long time, provided he was allowed a periodical rest. But he could not for many days, without great fatigue, march 20 miles a day with a 60 lb load, unless he were in good condition and well fed. If a greater amount still is demanded from him, he must have long subsequent rest. But all the long marches by our own or other armies have been made without weights, except arms and a portion of ammunition. Then great distances have been traversed by men in good training and condition.

SECTION III.

TRAINING.

The aim of the "Trainer" is to increase breathing power; to make the muscular action more vigorous and enduring, and to lessen the amount of fat. He arrives at his result by a very careful diet, containing little or no alcohol; by regular and systematic exercise; and by increasing the action of the eliminating organs, especially of the skin.

What the "Trainer" thus accomplishes is in essence the following: a concordant action is established between the heart and blood-vessels, so that the strong action of the heart during exercise is met by a more perfect dilatation of the vessels, and there is no blockage of the flow of blood; in the lungs, the blood not only passes more freely, but the amount of oxygen is increased, and the gradual improvement in breathing power is well seen when horses are watched during training. This reciprocal action of heart and blood-vessels is the most important point in training; the nutrition of nerves and muscular fibres improves from the constant action, and the abundant supply of food; the tissue changes are more active, and elimination, especially of carbon, increases. A higher condition of health ensues, and if not carried to excess, "training" is simply another word for healthy and vigorous living.[2]

[1] Training, by A. Maclaren, p. 168.

[2] Of course, over-training may be hurtful, but anything can be carried too far. Reference may be made to Dr. Morgan's highly interesting and well-worked out treatise on University Oars, to show that rowing is beneficial. Dr. Lee has published a useful little book, Exercise and Training, by R. Lee, M.D., with some good advice on training.

CHAPTER XIII.

CLOTHING.

The objects of clothing are to protect against cold and against warmth; all other uses will be found to resolve themselves into one or other of these.

The subject naturally divides itself into two parts—1st, The materials of clothing; and 2d, The make of the garments, which will be considered in Book II., and only as far as the soldier is concerned.

Materials of Clothing.

The following only will be described:—Cotton, linen, jute, wool, silk, leather, and india-rubber.

Chemical Reaction.—These materials are all easily distinguished by microscopical characters, but certain chemical reactions may be useful. Wool and silk dissolve in boiling liquor potassæ or liquor sodæ of sp. gr. 1040 to 1050; cotton and linen are not attacked. Wool is little altered by lying in sulphuric acid, but cotton and linen change in half an hour into a gelatinous mass, which is colored blue by iodine. Silk is slowly dissolved. Wool and silk take a yellow color in strong nitric acid; cotton and linen do not. So also wool and silk are tinged yellow by picric acid; cotton and linen are not, or the color is slight, and can be washed off. Silk, again, is dissolved by hot concentrated chloride of zinc, which will not touch wool. In a mixed fabric of silk, wool, and cotton, first boil in strong chloride of zinc, and wash; this gets rid of the silk; then boil in liquor sodæ, which dissolves the wool, and the cotton is left behind. Another reagent is recommended by Schlesinger, viz., a solution of copper in ammonia; this rapidly dissolves silk and cotton, and, after a longer time, linen; wool is only somewhat swollen by it. By drying thoroughly first, and after each of the above steps, the weight of the respective materials can be obtained.[1]

[1] If other fabrics than those mentioned in the text have to be examined, the best book to consult is Dr. Schlesinger's Mikroscopische Untersuch. der Gespinnst-Fasern (Zurich, 1873), where plates will be found of many of the fibres of commerce. The following are the chief reagents used by Schlesinger:—1st, Strong and weak sulphuric acid, to dissolve or swell out the fibres, and also, with iodine, to test for cellulose. 2d, Nitric acid, especially to show the markings. 3d, Chromic acid, as the best solvent for the intercellular substance, and for the swelling out in solution of the cellulose; it is often used with sulphuric acid. 4th, Dilute tincture of iodine, which is added to cellulose, and then sulphuric acid is used. 5th, Solution of copper, made by dissolving metallic copper in ammonia; this dissolves cell-membrane. 6th, Sulphate of aniline, which colors lignite yellow. 7th, Liquor potassæ (dilute), to render the fabrics transparent. He advises the fabric to be put on a slip of glass, and then a drop of water to be placed on it: then a needle should be drawn two or three times in the direction of the fibres, which will be easily detached. Then the fibre is laid on a glass and the reagent is applied.

Cotton—Microscopic Characters.—A diaphanous substance forming fibres about $\frac{1}{1000}$th of an inch in diameter, flattened in shape, and ribbon-like, with an interior canal which is often obliterated, or may contain some extractive matters, borders a little thickened, the fibres twisted at intervals (about 600 times in an inch). It has been stated that the fresh cotton fibre is a cylindrical hair with thin walls, which collapses and twists as it becomes dry. Iodine stains them brown; iodine and sulphuric acid (in very small quantities) give a blue or violet-blue; nitric acid does not destroy them, but unrolls the twists.

As an Article of Dress.—The fibre of cotton is exceedingly hard, it wears well, does not shrink in washing, is very non-absorbent of water



Fig. 93.—Cotton × 285.



Fig. 94.—Linen × 285.

(either into its substance, or between the fibres), and conducts heat rather less rapidly than linen, but much more rapidly than wool.[1]

The advantages of cotton are cheapness and durability; its hard non-absorbent fibre places it far below wool as a warm water-absorbing clothing. In the choice of cotton fabrics there is not much to be said; smoothness, evenness of texture, and equality of spinning, are the chief points.

In cotton shirting and calico, cotton is alone used; in merino and other fabrics it is used with wool, in the proportion of 20 to 50 per cent. of wool, the threads being twisted together to form the yarn.

Linen—Microscopic Characters.—The fibres are finer than those of

[1] Experiments on the conducting power of materials by Coulier (Professor of Chemistry at the Val de Grâce), and by Dr. Hammond (late Surgeon-General, United States Army).

cotton, diaphanous, cylindrical, and presenting little swellings at tolerably regular intervals. The elementary fibres (of which the main fibre is composed) can be often seen in these swellings, and also at the end of broken threads which have been much used. The hemp fibre is something like



FIG. 95.—Silk × 285.

this, but much coarser, and at the knots it separates often into a number of smaller fibres. *Silk* is a little like linen, but finer, and with much fewer knots.

As an Article of Clothing.—Linen conducts heat and absorbs water

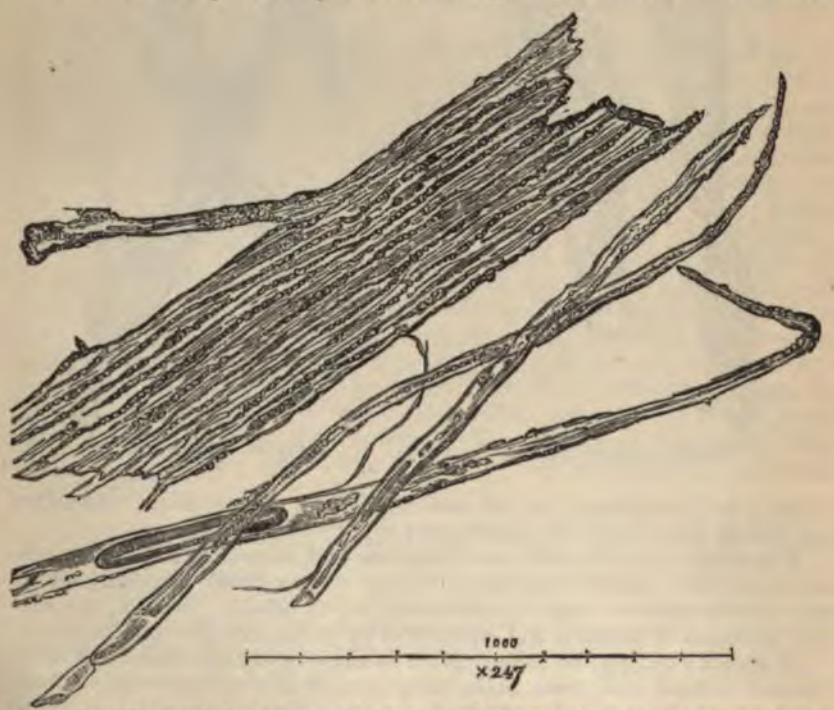


FIG. 96.—Jute—United and single elongated Cellular Tissues. Resinous (?) matter adhering more or less to all the fibres.

slightly better than cotton. It is a little smoother than cotton. As an article of clothing it may be classed with it. In choosing linen regard is had to the evenness of the threads, and to the fineness and closeness of the

texture. The color should be white, and the surface glossy. Starch is often used to give glossiness. This is detected by iodine, and removed by the first washing.

Jute.—Jute is now very largely used, and appears to enter into the adulteration of most fabrics. Jute is obtained from the *Corchorus capsularis*, and comes to England from Russia and India. The fibres are of considerable length, are hollow, thickened, and with narrowings and constrictions in the tubular portions; sometimes an air-bubble may be in the fibre, as shown in the drawing. The drawing, by Dr. Maddox, shows the differences between the jute and cotton or linen.

Wool—Microscopic Characters.—Round fibres, transparent or a little hazy, colorless, except when artificially dyed. The fibre is made up of a number of little cornets, which have become united. There are very evident slightly oblique cross markings, which indicate the bases of the cornets; and at these points the fibre is very slightly larger. There are also fine longitudinal markings. There is a canal, but it is often obliterated. When old and worn, the fibre breaks up into fibrillæ; and, at the same time, the slight prominence at the cross markings disappear, and even the markings become indistinct. By these characters old wool can be recognized. Size of fibres varies, but an average is given by the figure. The finest wools have the smallest fibres.



FIG. 97.—Wool × 285.

As an Article of Clothing.—Wool is a bad conductor of heat and a great absorber of water. The water penetrates into the fibres themselves and distends them (hygroscopic water), and also lies between them (water of interposition). In these respects it is greatly superior to either cotton or linen, its power of hygroscopic absorption being at least double in proportion to its weight, and quadruple in proportion to its surface.

This property of hygroscopically absorbing water is a most important one. During perspiration the evaporation from the surface of the body is necessary to reduce the heat which is generated by the exercise. When the exercise is finished, the evaporation still goes on, and, as already noticed, to such an extent as to chill the frame. When dry woollen clothing is put on after exertion, the vapor from the surface of the body is condensed in the wool, and gives out again the large amount of heat which had become latent when the water was vaporized. Therefore a woollen covering, from this cause alone, at once feels warm when used during sweating. In the case of cotton and linen the perspiration passes through them, and evaporates from the external surface without condensation; the loss of heat then continues. These facts make it plain why dry woollen clothes are so useful *after* exertion.[1]

[1] Pettenkofer gives (Zt. für Biol., Band i., p. 185) some experiments showing the hygroscopic power of wool as compared with linen. He shows that linen not only absorbs much less water, but parts with it much more quickly; thus, to cite one experiment,

In addition to this, the texture of wool is warmer, from its bad conducting power, and it is less easily penetrated by cold winds. The disadvantage of wool is the way in which its soft fibre shrinks in washing, and after a time becomes smaller, harder, and probably less absorbent.[1]

In the choice of woollen underclothing the touch is a great guide. There should be smoothness and great softness of texture; to the eye the texture should be close; the hairs standing out from the surface of equal length, not long and straggling. The heavier the substance is, in a given bulk, the better. In the case of blankets, the softness, thickness, and closeness of the pile, the closeness of the texture, and the weight of the blanket, are the best guides.

In woollen cloth the rules are the same. When held against the light, the cloth should be of uniform texture, without holes; when folded and suddenly stretched, it should give a clear ringing note; it should be very resistent when stretched with violence; the "tearing power" is the best way of judging if "shoddy" (old used and worked-up wool and cloth) has been mixed with fresh wool. A certain weight must be borne by every piece of cloth. At the Government Clothing Establishment at Pimlico, a machine is used which marks the exact weight necessary to tear across a piece of cloth. Schlesinger recommends the following plan for the examination of a mixed fabric containing shoddy:—Examine it with a microscope, and recognize if it contains cotton, or silk, or linen, besides wool. If so, dissolve them by ammoniacal solution of copper. In this way a qualitative examination is first made. Then fix attention on the wool. In shoddy both colored and colorless wool-fibres are often seen, as the fibres have been derived from different cloths which have been partially bleached; the coloring matter, if it remains, is different—indigo, purpurin, or madder. The diameter of the wool is never so regular as in fresh wool, and it changes suddenly or gradually in diameter, and suddenly widens again with a little swelling, and then thins off again; the cross marking or scales are also almost obliterated. When liquor potassæ is applied the shoddy wool is attacked much more quickly than fresh wool.

The dye also must be good, and of the kind named in the contract, and tests must be applied.

Leather.—Choice of leather; it should be well tanned, and without any marks of corrosion, or attacks of insects. The thinner kind should be perfectly supple.

Leather is not only used for shoes, leggings, and accoutrements; it is employed occasionally for coats and trousers. It is an extremely warm clothing, as no wind blows through it, and is therefore well adapted for cold, windy climates. Leather or sheepskin coats are very common in

equal surface of linen and flannel being exposed to the air after being placed in equal conditions of absorption, the linen lost in 75 minutes 5.993 grammes, and the flannel only 4.858 grammes of water. Subsequently the evaporation from the linen lessened, as was to be expected, as it was becoming drier; that from the flannel continued to pass off moderately. The much greater cooling effect of linen is seen.

The porosity of clothing, *i.e.*, the rapidity with which air is driven through, is a point to be noted. By an equal pressure equivalent to a column of water 4.5 centimetres high, an area of 1 centimetre diameter forced air through as follows:—Through linen, 6.03 litres; flannel, 10.41; lambskin, 5.07; glove-leather, .15; wash-leather, 5.37; silk-fabric, 4.14.

It thus appears that the warmest clothing (flannel) may be the most porous; mere porosity, in fact, is only one element in the consideration.

[1] In washing woollen articles, they should never be *rubbed* or *wrung*. They should be placed in a hot solution of soap, moved about, and then plunged into cold water; when the soap is got rid of they should be hung up to dry without wringing.

Turkey, Tartary, Persia, the Danubian Provinces, and everywhere where the cold north winds are felt. In Canada, coats of sheepskin or buffalo-hide have been found very useful, and are commonly used by sentries.

Waterproof Clothing,—Like leather articles, the india-rubber is an exceedingly hot dress, owing to the same causes, viz., impermeability to wind, and condensation and retention of perspiration. It is objected to by many on these grounds, and especially the latter; and Lévy informs us that the Council of Health of the French Army have persistently refused (and, in his opinion, very properly) the introduction of waterproof garments into the army. If, however, woollen underthings are worn, the perspiration is sufficiently absorbed by those during the comparatively short time waterproof clothing is worn, and the objection is properly not valid, unless the waterproof is continually worn.

The great use of waterproof is, of course, its protection against rain, and in this respect it is invaluable to the soldier, and should be largely used. By the side of this great use, all its defects appear to be minor evils.

India-rubber cloth loses in part its distensibility in very cold countries, and becomes too distensible in the tropics. It is also apt to rot by absorption of oxygen. Paraffined cloth is equally good, and the paraffin does not rot the fibre like common oil.

General Conclusions.

Protection against Cold.—For equal thicknesses, wool is much superior to either cotton or linen, and should be worn for all underclothing. In case of extreme cold, besides wool, leather, or waterproof clothing is useful. Cotton and linen are nearly equal.

Protection against Heat.—Texture has nothing to do with protection from the direct solar rays; this depends entirely on color. White is the best color; then gray, yellow, pink, blue, black. In hot countries, therefore, white or light gray clothing should be chosen.

In the shade, the effect of color is not marked. The thickness, and the conducting power of the material, are the conditions (especially the former) which influence heat.

Protection against Cold Winds.—For equal thicknesses, leather and india-rubber take the first rank; wool the second; cotton and linen about equal.

Absorption of Perspiration.—Wool has more than double the power of cotton and linen.

Absorption of Odors.—This partly depends on color; and Stark's observations show that the power of absorption is in this order—black, blue, red, green, yellow, white. As far as texture is concerned, the absorption is in proportion to the hygroscopic absorption, and wool therefore absorbs more than cotton or linen.

Protection against Malaria.—It has been supposed that wearing flannel next the skin lessens the risk of malaria. As it is generally supposed that the poison of malaria enters either by the lungs or stomach, it is difficult to see how protection to the skin can prevent its action; except indirectly, by preventing chill in persons who have already suffered from ague. But the very great authority of Andrew Combe, drawn from experience at Rome, is in favor of its having some influence; and it has been used on the west coast of Africa for this purpose, with apparently good results.

CHAPTER XIV.

CLIMATE.

It is not easy to give a proper definition of climate. The effect of climate on the human body is the sum of the influences which are connected either with the solar agencies, the soil, the air, or the water of a place, and as these influences are in the highest degree complex, it is not at present possible to trace out their effects with any certainty.

With regard generally to the effect of climate on human life, it would seem certain that the facility of obtaining food (which is itself influenced by climate), rather than any of the immediate effects of climate, regulates the location of men and the amount of population. The human frame seems to acquire in time a wonderful power of adaptation; the Eskimos, when they can obtain plenty of food, are large strong men (though nothing is known of their average length of life), and the dwellers in the hottest parts of the world (provided there is no malaria, and that their food is nutritious) show a stature as lofty, and a strength as great, as any dwellers in temperate climates. Peculiarities of race, indeed, arising no one knows how, but probably from the combined influences of climate, food, and customs, acting through many ages, appear to have more effect on stature, health, and duration of life, than climate alone. Still, it would seem probable that, in climatic conditions so diverse, there arise some special differences of structure which are most marked in the skin, but may possibly involve other organs.

How soon the body, when it has become accustomed by length of residence for successive generations to one climate, can accommodate itself to, or bear the conditions of, the climate of another widely different place, is a question which can only be answered when the influences of climate are better known. The hypothesis of "acclimatization" implies that there is at first an injurious effect produced, and then an accommodation of the body to the new conditions within a very limited time; that, for example, the dweller in northern zones passing into the tropics, although he at first suffers, acquires in a few years some special constitution which relieves him from the injurious consequences which, it is supposed, the change at first brought with it. There are, therefore, two assumptions, viz., of an injurious effect, and of a relief from it. Are either correct?

It may seem a bold thing to question the commonly received opinion, that a tropical climate is injurious to a northern constitution, but there are some striking facts which it is difficult to reconcile with such an opinion. The army experience shows that, both in the West Indies and in India, the mortality of the soldier has been gradually decreasing, until, in some stations in the West Indies (as, for example, Trinidad and Barbadoes), the sickness and mortality among the European soldiers are actually less than on home service in years which have no yellow fever. In India, a century

ago, people spoke with horror of the terrible climate of Bombay and Calcutta, and yet Europeans now live in health and comfort in both cities. In Algeria the French experience is to the same effect. As the climate and the stations are the same, and the soldiers are of the same race and habits, what has removed the dangers which formerly made the sickness threefold and the mortality tenfold the ratio of the sickness and deaths at home?

The explanation is very simple; the deaths in the West Indies were partly owing to the virulence of yellow fever (which was fostered, though probably not engendered by bad sanitary conditions), and the general excess of other febrile and dysenteric causes. The simple hygienic precautions which are efficacious in England, have been as useful in the West Indies. Proper food, good water, pure air, have been supplied, and, in proportion as they have been so, the deadly effects attributed to climate have disappeared. The effect of a tropical climate is, so to speak, relative. The temperature and the humidity of the air are highly favorable to decompositions of all kinds; the effluvia from an impure soil, and the putrescent changes going on in it, are greatly aggravated by heat. The effects of the sanitary evils which, in a cold climate like Canada, are partly neutralized by the cold, are developed in the West Indies, or in tropical India, to the greatest degree. In this way a tropical climate is evidently most powerful, and it renders all sanitary precautions tenfold more necessary than in the temperate zone. But all this is not the effect of climate, but of something added to climate.

Take away these sanitary defects, and avoid malarious soils or drain them, and let the mode of living be a proper one, and the European soldier does not die faster in the tropics than at home.

It must be said, however, that an element of uncertainty may be pointed out here. In our tropical possessions the European soldier serves now only for short periods (in the West Indies for three or four years, in India, under the new regulations of short service, seven or eight years, at most), and during this time he may be for some years on the hills, or at any rate in elevated spots. The old statistical reports of the army pointed out that the mortality in the West Indies augmented regularly with prolongation of service, and it may be said that, after all, the lessened sickness and mortality in the tropics is owing, in some degree, to avoidance by short service of the influence of climate. But as the whole long service was constantly passed under the unfavorable sanitary conditions now removed, it does not follow that the inference to be drawn from the statistical evidence as to length of service is really correct.

Facts prove, then, that under favorable sanitary conditions (general and personal), Europeans, during short services, may be as healthy as at home, as far as shown by tables of sickness and mortality, and it is not certain that long service brings with it different results.

It may, however, be urged that, admitting that a non-malarious tropical climate, *per se*, may not increase sickness or mortality during the most vigorous years of life (and it is then only that Europeans are usually subjected to it), it may yet really diminish health, lessen the vigor of the body, and diminish the expectation of life.

We have no evidence on the latter point. With respect to the former, it will be well to see what is known of the effects of climatic agencies on the frame.

The influences of locality and climate, as far as they are connected with soil and water, have been sufficiently discussed. The climatic conditions most closely (though by no means solely) connected with air will now be

briefly reviewed. These are—temperature, humidity, movement, weight, composition, and electrical condition, and the amount of light.

SECTION I.

TEMPERATURE.

The amount of the sun's rays; the mean temperature of the air; the variations in temperature, both periodic and non-periodic; and the length of time a high or low temperature lasts, are the most important points. Temperature alone has been made a ground of classification.

(*a*) *Equable, limited,* or *insular* climates; *i.e.*, with slight yearly and diurnal variations.

(*b*) *Extreme, excessive,* or *continental; i.e.*, with great variations.

The terms *limited* and *extreme* might be applied to the amplitude of the yearly fluctuation (*i.e.*, difference between hottest and coldest month), while *equable* and *excessive* might be applied especially to the non-periodic variations, which are slight in some places and extreme in others.

A limited climate is generally an equable one, and an extreme climate (with great yearly fluctuation) is generally an excessive one (with great undulations).

The effects of heat cannot be dissociated from the other conditions; it is necessary, however, briefly to notice them.

The effect of a certain degree of temperature on the vital processes of a race dwelling generation after generation on the same spot, is a question which has as yet received no sort of answer. Does the amount of heat *per se*, independent of food and all other conditions, affect the development of mechanical force and temperature, and the coincident various processes of formation and destruction of the tissues? Is there a difference in these respects, and in the resulting action of the eliminating organs, in the inhabitants of the equator and of 50° or 60° N. lat.? This is entirely a problem for the future, but there is no class of men who have more opportunities of studying it than army surgeons.

The problem of the influence of temperature is generally presented to us under the form of a dweller in a temperate zone proceeding to countries either colder or hotter than his own. It is in this restricted sense we shall now consider it.

With regard to the effect on the Anglo-Saxon and Celtic races of going to live in a climate with a lower mean temperature and greater variations than their own, we have the experience of Canada, Nova Scotia, and some parts of the Northern American States. In all these, if food is good and plentiful, health is not only sustained, but is perhaps improved. The agricultural and out-door life of Canada or Nova Scotia is probably the cause of this; but certain it is that in those countries the European not only enjoys health, but produces a progeny as vigorous, if not more so, than that of the parent race.

The effects of heat exceeding the temperate standard must be distinguished according to origin; radiant heat, or the direct rays of the sun, and non-radiant heat, or that of the atmosphere. In the latter case, in addition to heat there is more or less rarefaction of the air, and also coincident conditions of humidity and movement of the air, which must be taken into account. The influence, again, of sudden transitions from heat to cold, or the reverse, has to be considered. Europeans from temperate climates

flourish, apparently, in countries not much hotter than their own, as in some parts of Australia, New Zealand, and New Caledonia, though it is yet too soon to speculate whether the vigor of the race will improve or otherwise. But there is a general impression that they do not flourish in countries much hotter, *i.e.*, with a yearly mean of 20° Fahr. higher, as in many parts of India; that the race dwindles, and finally dies out; and therefore that no acclimatization of race occurs. And certainly it would appear that in India there is some evidence to show that the pure race, if not intermixed with the native, does not reach beyond the third generation. Yet it seems only right to say that so many circumstances besides heat and the other elements of climate have been acting on the English race in India, that any conclusion opposed to acclimatization must be considered as based on scanty evidence. We have not gauged on a large scale the effects of climate pure and simple, uncomplicated with malaria, bad diet, and other influences adverse to health and longevity.[1]

(*a*) *Influence of the Direct Rays of the Sun.*—It is not yet known to what temperature the direct rays of the tropical sun can raise any object on which they fall. In India, on the ground, the uncovered thermometer will mark 160°, and perhaps 212° (Buist); and in this country, if the movement of air is stopped in a small space, the heat in the direct sun's rays can be raised to the same point. In a box, with a glass top, Sir H. James found the thermometer mark 237° Fahr., when exposed to the rays of the sun, on July 14, 1864.[2] In experiments on frogs, when temperature much over the natural amount is applied to nerves, the electrical currents through them are lessened, and at last stop.[3] E. H. Weber's observations show that for men the same rule holds good; the most favorable temperature is 30° R. (= 99.5° Fahr.).[4] It appears also from Kuhne's experiments that the heat of the blood of the vertebrata must not exceed 113° Fahr., for at that temperature the myosin begins to coagulate.[5] Perhaps this fact may be connected with the pathological indication that a very high temperature in any disease (over 110° Fahr.) indicates extreme danger.

To what temperature is the skin of the head and neck raised in the tropics in the sun's rays? No sufficient experiments have been made, either on this point or on the heat in the interior of caps and hats with and without ventilation. Doubtless, without ventilation, the heat above the head in the interior of the cap is very great. It is quite possible, as usually assumed, that with bad head-dresses the heat of the skin, bones, and possibly even of the deep nerves and centres (the brain and cord), may be greater than is accordant with perfect preservation of the currents of the nerves, or of the necessary temperature of the blood, or with the proper fluidity of some of the albuminous bodies in the muscles, or nerves.

The difficulty of estimating the exact effect of the solar rays is not only caused by the absence of a sufficient number of experiments, but by the common presence of other conditions, such as a hot rarefied, and perhaps

[1] In India the mortality of Eurasians (that is, the mixed race of British, Portuguese, Hindoo, Malay, blood) mixed in all degrees appears to be below that of the most healthy European service, viz., the Civil Service. Mr. Tait's facts "On the Mortality of Eurasians" (Statistical Journal, September, 1864) would show that this mixed race will maintain itself in India.

[2] Mr. Symons has also obtained temperature above 212° F. by the same means.

[3] Eckhard, Henle's Zeitsch., Band x., p. 165, 1851.

[4] Weber, Ludwig's Phys., 2d ed., vol. i., p. 126.

[5] Ludwig, Lehrb. der Phys., Band ii., p. 732. For a collection of data, see Dr. H. C. Wood, jun., Thermic Fever, 1872, p. 50.

impure air, and heat of the body produced by exercise, which is not attended by perspiration. Two points are remarkable in the history of sunstroke, viz., the extreme rarity of sunstroke in mid ocean [1] and at great elevations.[2] In both cases the effect of the sun's rays, *per se*, is not less, is even greater, than on land and at sea-level; yet in both sunstroke is uncommon; the temperature of the air, however, is never excessive in either case.

The effect of the direct rays on the skin is another matter requiring investigation. Does it aid or check perspiration? That the skin gets dry there is no doubt, but this may be merely from rapid evaporation. But if the nervous currents are interfered with, the vessels and the amount of secretion are sure to be affected, and on the whole it seems probable that a physiological effect adverse to perspiration is produced by the direct rays of the sun. If so, and if this is carried to a certain point, the heat of the body must rise, and supposing the same conditions to continue (intense radiant heat and want of perspiration), may pass beyond the limit of the temperature of possible life (113° Fahr.).[3]

The effect of intense radiant heat on the respiration and heart is another point of great moment which needs investigation.

The pathological effect produced by the too intense direct rays of the sun is seen in one or two forms of insolation, and consists in paralysis of the heart or the respiration.

A form of fever (the *Causus* of some writers, or thermic fever) has been supposed to be caused by the direct rays of the sun combined with excessive exertion. Dr. Parkes mentions a case of this kind which corresponded closely to the description in books. The fever lasted for several days, and its type was not in accordance with the hypothesis that it was malarious fever, or febricula, or typhoid. No thermometric observations were made on the patient.

(*b*) *Heat in Shade.*—The effect of high air temperature on the native of a temperate climate passing into the tropics has not been very well determined, and some of the conclusions are drawn from experiments on animals exposed to an artificial temperature.

1. The *temperature* of the body does not rise greatly—not more than .5 or 1° Fahr. (John Davy); from 1° to 2½° and 3° (Eydaux and Brown-Séquard). In some experiments not yet published, Dr. Becher determined his own temperature in a very careful way during a voyage round the Cape to India. He found the body-heat increased, and in the proportion of 0.05° Fahr. for every increase of 1° Fahr. in the air. Rattray also found a decided increase, varying from 0.2° Fahr. to 1.2° Fahr.; the greatest increase was in the afternoon. We may conclude that the tropical heat raises the temperature of the body of a new-comer, probably because the evaporation from the skin is not capable of counterbalancing the great additional external heat, but it is now known that in old residents the same fact does not hold

[1] The cases of insolation in a narrow sea like the Red Sea do not invalidate this rule.

[2] This may be due to the absence of radiation from the ground; ground radiation affects unprotected thermometers very markedly.

[3] In the Turkish bath it may sometimes be observed, that on entering the hottest chamber the skin, which had previously been acting freely, becomes dry. A feeling of oppression accompanies this, but relief is experienced so soon as perspiration is re-established. This would seem to point more to an actual arrest of function than to a mere drying up of the secretion. The same thing in a modified degree may occur in a tropical climate, in which case the intensity of fever will depend upon the time that elapses before accommodation is reached.

good. Brigade-Surgeon J. C. Johnston, A.M.D., has recorded a very careful series of experiments, made on soldiers of at least three years' service in India,[1] in the station of Bellary. The average of one series was 97.63°, and of another 97.94°, thus showing if anything a slight lowering from the normal temperature, 98.4°. Surgeon-Major Boileau, from a long series of observations in the West Indies, came to the conclusion that there was no material rise. The temperature of the body is the result of the opposing action of two factors—1st, of development of heat from the chemical changes of the food, and by the conversion of mechanical energy into heat, or by direct absorption from without; and, 2d, and opposed to this, of evaporation from the surface of the body, which regulates internal heat. So beautifully is this balance preserved, that the stability of the animal temperature in all countries has always been a subject of marvel. If anything, however, prevents this evaporation, radiation and the cooling effect of moving wind cannot cool the body sufficiently in the tropics. Then, no doubt, the temperature of the body rises, especially if in addition there is muscular exertion and production of heat from that cause. The extreme discomfort always attending abnormal heat of body then commences. In experiments in ovens, Blagden and Fordyce bore a temperature of 260° with a small rise of temperature (2½° Fahr.), but the air was dry, and the heat of their bodies was reduced by perspiration; when the air in ovens is very moist and evaporation is hindered, the temperature of the body rises rapidly.[2]

2. The *respirations* are lessened in number (Vierordt, Ludwig) in animals subjected to heat. According to Vierordt, less carbonic acid and presumably less water are eliminated. Rattray [3] proved by a great number of observations that the number of respirations is lessened in persons passing from a cold to a hot climate. The amount of diminution varies; in some experiments the fall was from 16.5 respirations per minute in England, in winter, to 12.74 and 13.74 in the tropics. In another series of experiments the fall was from 17.3 respirations per minute to 16.1; the breathing is also gentler, *i.e.*, less deep. Rattray has also shown that the spirometric measurement of the expired air ("vital capacity" of Hutchinson) increases in the tropics and falls in temperate climates, the average variation being about 8.7 per cent. of the total spirometric measurement.[4] This will hold good at all ages, but is less at either extreme of life, and is most marked in persons of largest frame and most full-blooded. The explanation of this spirometric increase in the respiratory action of the lungs, as compared with the lessened number of inspirations, is to be found, according to Rattray, in a lessened proportion of blood and a larger proportion of air in the lungs in the tropics, and this is borne out by a fact presently to be noted, of the lessened weight of the lungs in Europeans in the tropics.

The effect of the lessened number of respirations is (in spite of the spirometric increase) to reduce the total respiratory action considerably.

[1] Army Medical Reports, vol. xviii., p. 255.

[2] It rises even 7° to 8° Fahr. (Ludwig, Lehrb. des Phys., 2d edit., b. ii., p. 730). Obernier's late observations are confirmatory (Der Hitzschlag, Bonn, 1867). Obernier confirms the pathology generally received in this country. From an observation of four cases of sunstroke, and from thirty-three experiments on animals exposed to artificial heat, he traces all the effects to the augmented temperature of the body, which cannot cool by evaporation from the surface and lungs as usual. Dr. H. C. Wood, jun., of Philadelphia (Thermic Fever or Sunstroke, 1872), also holds that the "efficient cause of sunstroke is the excess of temperature."

[3] On the Effects of Change of Climate on the Human Economy, by A. Rattray, M.D., Surgeon, R.N., Proceedings of the Royal Society, Nos. 122–126, 139 (1869–72).

[4] Proceedings of the Royal Society, No. 139, p. 2.

Rattray has shown that the average amount is in the temperate zone (temp. = 54° Fahr.), 239.91 cubic inches per minute, while in the tropics (= 82° Fahr.) only 195.69 cubic inches were inspired, so that there is a difference of 38.65 cubic feet in twenty-four hours, or 18.43 per cent. in favor of a temperate climate. If 10 ounces of carbon are expired in the temperate zone, only 8.157 ounces would be expired in the tropics. Is there then greater excretion of carbon from the skin, or, as used to be supposed, from the liver?

Dr. Francis (Bengal Army) has observed that the lungs are lighter after death in Europeans in India than the European standard. Dr. Parkes made a similar observation many years ago, and recorded it in a work on cholera,[1] but the facts were few. If this statement be confirmed, it would show a diminished respiratory function, and would accord with Rattray's observations.

3. The *heart's* action has been usually stated to be quickened in the tropics, but Rattray's numerous observations show that this is incorrect; the average pulse in the tropics was lower by 2½ beats per minute than in the temperate zone. In experiments on animals, moderate heat does not quicken the heart, but great heat does.

4. The *digestive* powers are somewhat lessened, there is less appetite, less desire for animal food, and more wish for cool fruit. The quantity of bile secreted by the liver is not increased, if the stools are to be taken as a guide (Marshall, in 1819, John Davy, Morehead, Parkes), though Lawson believes that an excess of coloring matter passes out with the stools; nothing is known of the condition of the usual liver work.

5. The *skin* acts much more than usual (an increase of 24 per cent. according to Rattray), and great local hyperæmia and swelling of the papillæ occur in new-comers, giving rise to the familiar eruption known as "prickly heat." In process of time, if exposed to great heat, the skin suffers apparently in its structure, becoming of a slight yellowish color from, probably, pigmentary deposits in the deep layers of the cuticle.

6. The *urine* is lessened in quantity. The urea is lessened, as shown by experiments in hot seasons at home and during voyages (Dr. Forbes Watson and Dr. Becher).[2] It is probable that this is simply from lessened food. The pigment has been supposed to be increased (Lawson), but this is doubtful. The chloride of sodium is lessened; the amount of uric and phosphoric acids is uncertain.

7. The effect on the *nervous* system is generally considered as depressing and exhausting, *i.e.*, there is less general vigor of mind and body. But it is undoubted that the greatest exertions both of mind and body have been made by Europeans in hot climates. Robert Jackson thought as much work could be got out of men in hot as in temperate climates. It is probable that the depressing effects of heat are most felt when it is combined with great humidity of the atmosphere, so that evaporation from the skin, and consequent lessening of bodily heat, are partly or totally arrested.[3]

[1] On Algide Cholera, by E. A. Parkes, M.D., p. 14 (1847).

[2] These experiments are not yet fully published; they were made during voyages to Bombay and China, and show that when the temperature reached a certain point (75° in Dr. Becher's experiments), the solids of the urine and the urea lessened considerably (Proceedings of the Royal Society, 1862).

[3] See Dr. Kenneth Mackinnon's Treatise on Public Health, p. 27, on the effect of plenty of exercise even in the hot, and moist, and presumed unhealthy climate of Tirhoot, in Bengal. He proves that men can be much in the open air, even in the hot parts of the day, with impunity, and that when "they take exercise they are in the highest state of health." Still Dr. Mackinnon believes the climate is exhausting.

The most exhausting effects of heat are felt when the heat is continuous, *i.e.*, very great, day and night, and especially in sandy plains, where the air is highly rarefied day and night. There is then really lessened quantity of oxygen in a given cubic space. Add to this fact that the respirations are lessened, and we have two factors at work which must diminish the ingress of oxygen, and thereby lessen one of the great agents of metamorphosis.

8. Rattray made observations[1] on the *weight* and *height* of forty-eight naval cadets, aged from 14½ to 17 years, during four successive changes of climate during a voyage. The results show that in the tropics they increased in height more rapidly than in cold climates, but that they lost weight very considerably, and, in spite of their rapid growth, Rattray concludes that the heat impaired the strength, weight, and health of these lads. His figures seem conclusive on these points, and show the beneficial influence of cold on youths belonging to races long resident in temperate climates.

On the whole, even when sufficient perspiration keeps the body temperature within the limits of health, the effect of great heat in shade seems to be, as far as we can judge, a depressing influence lessening the nervous activity, the great functions of digestion, respiration, sanguification, and directly or indirectly the formation and destruction of tissues. Whether this is the heat alone, or heat and lessened oxygen, and great humidity, is not certain.

So bad have been the general and personal hygienic conditions of Europeans in India, that it is impossible to say what amount of the great mortality in that country is due to excess of heat over the temperature of Europe. Nor is it possible to determine the influence of heat alone on the endemic diseases of Europeans in the tropics—liver disease and dysentery. There is, perhaps, after all, little immediate connection between heat and liver disease.

Rapid Changes of Temperature.—The exact physiological effects have not yet been traced out; and these sudden vicissitudes are often met by altered clothing, or other means of varying the temperature of the body. The greatest influence of rapid changes of temperature appears to occur when the state of the body in some way coincides with or favors their action. Thus, the sudden checking of the profuse perspiration by a cold wind produces catarrhs, inflammations, and neuralgia. It is astonishing, however, to find how well even phthisical persons will bear great changes of temperature, if they are not exposed to moving currents of air; and there can be little doubt that the wonderful balance of the system is soon readjusted.

SECTION II.

HUMIDITY.

According to their degree of humidity, climates are divided into moist and dry. Professor Tyndall's observations have shown how greatly the humidity of the air influences climate, by hindering the passage of heat from the earth. As far as the body is concerned, the chief effect of moist air is exerted on the evaporation from the skin and lungs, and therefore the degree of dryness or moisture of an atmosphere should be expressed in terms of the relative (and not of the absolute) humidity, and should always be taken in connection with the temperature, movement, and density of

[1] Proceedings of the Royal Society, No. 139.

the air, if this latter varies much from that of sea-level. The evaporating power of an atmosphere which contains 75 per cent. of saturation is very different, according as the temperature of the air is 40° or 80°. As the temperature rises, the evaporative power increases faster than the rise in the thermometer.

There is a general opinion that an atmosphere which permits free, without excessive, evaporation is the best; but there are few precise experiments.

The most agreeable amount of humidity to most healthy people is when the relative humidity is between 70 and 80 per cent. In chronic lung diseases, however, a very moist air is generally most agreeable, and allays cough. The evaporation from the lungs produced by a dry atmosphere appears to irritate them.

The moist hot siroccos, which are almost saturated with water, are felt as oppressive by man and beast; and this can hardly be from any other cause than the check to evaporation, and the consequent rise in the temperature of the body.

It is not yet known what rate of evaporation is the most healthy. Excessive evaporation, such as may be produced by a dry sirocco, is well borne by some persons, but not by all. Probably, in some cases, the physiological factor of perspiration comes into play, and the nerves and vessels of the skin are altered; and in this way perspiration is checked. We can hardly account, in any other way, for the fact, that in some persons, the dry sirocco, or dry hot land wind, produces harshness and dryness of the skin, and general malaise, which possible (though there is yet no thermometric proof) may be caused by a rise of temperature of the body.

From the experiments of Lehmann on pigeons and rabbits, it appears that more carbon dioxide is exhaled from the lungs in a very moist than in a dry atmosphere. The pathological effects of humidity are intimately connected with the temperature. Warmth and great humidity are borne on the whole more easily than cold and great humidity. Yet in both cases, so wonderful is the power of adaptation of the body, that often no harm results.

The spread of certain diseases is supposed to be intimately related to humidity of the air. Malarious diseases, it is said, never attain their fullest epidemic spread unless the humidity approaches saturation. Plague and smallpox are both checked by a very dry atmosphere. The cessation of bubo plague in Upper Egypt, after St. John's Day, has been considered to be more owing to the dryness than to the heat of the air.

In the dry Harmattan wind, on the west coast of Africa, smallpox cannot be inoculated; and it is well known with what difficulty cowpox is kept up in very dry seasons in India. Yellow fever, on the other hand, seems independent of moisture, or will at any rate prevail in a dry air. The observations at Lisbon, which Lyons has recorded, show no relation to the dew-point.

With regard to other diseases, and especially to diseases of sanguification and nutrition, observations are much needed.

SECTION III.

MOVEMENT OF AIR.

This is a very important climatic condition. The effect on the body is twofold. A cold wind abstracts heat, and in proportion to its velocity; a hot wind carries away little heat by direct abstraction, but, if dry, increases evaporation, and in that way may in part counteract its own heating power. Both, probably, act on the structure of the nerves of the skin and on the contractility of the cutaneous vessels, and may thus influence the rate of evaporation, and possibly affect also other organs.

The amount of the cooling effect of moving bodies of air is not easy to determine, as it depends on three factors, viz., the velocity of movement, the temperature, and the humidity of the air. The effect of movement is very great. In a calm atmosphere an extremely warm temperature is borne without difficulty. In the Arctic expeditions calm air many degrees below zero of Fahr. caused no discomfort. But any movement of such cold air at once chills the frame. It has been asserted that some of the hot and very dry desert winds will, in spite of their warmth, chill the body; and if so, it can scarcely be from any other reason than the enormous evaporation they cause from the skin. It is very desirable, however, that this observation should be repeated, with careful thermometrical observations both on the body in the usual way and on the surface of the skin.

SECTION IV.

WEIGHT OF THE AIR.

Effects of Considerable Lessening of Pressure.

When the difference of pressure between two places is considerable, a marked effect is produced, and there seems no doubt that the influence of mountain localities is destined to be of great importance in therapeutics. It is of peculiar interest to the army surgeon, as so many regiments in the tropics are, or will be, quartered at considerable elevations.

In ascending mountains there is rarefaction, *i.e.*, lessened pressure of air; on an average (if the weight of the air at sea-level is 15 lb on every square inch) an ascent of 900 feet takes off ½ lb; but this varies with height; there are also lowered temperature, and lessened moisture above 4,000 feet, greater movement of the air, increased amount of light, greater sun radiation, if clouds are absent; the air is freer from germs of infusoria; owing to the rarefaction of the air and lessened watery vapor, there is greater diathermancy of the air; the soil is rapidly heated, but radiates also fast, as the heat is not so much held back by vapor in the air, hence there is very great cooling of the ground and the air close to it at night.

The physiological effects of lessened pressure begin to be perceptible at 2,800 or 3,000 feet of altitude (= descent of 2½ to 3 inches of mercury); they are—quickened pulse[1] (fifteen to twenty beats per minute);

[1] Balloon ascents.—Biot & Gay-Lussac at 9,000 ft. = increase of 18–30 beats of pulse.
Glaisher.....at 17,000 " = " of 10–24 "
Glaisher.....at 24,000 " = " of 24–31 "
The beats seem to augment in number with the elevation. These are safer numbers than those obtained in mountain ascents, as there is no physical exertion. In mountain climbing the increase is much greater.

quickened respiration (increase = ten to fifteen respirations per minute), with lessened spirometric capacity,[1] increased evaporation from skin and lungs; lessened urinary water.[2] At great heights there is increased pressure of the gases in the body against the containing parts; swelling of superficial vessels, and occasionally bleeding from the nose or lungs. A sensation of weight is felt in the limbs from the lessened pressure on the joints. At altitudes under 6,000 or 7,000 feet the effect of mountain air (which is, perhaps, not owing solely to lessened pressure, but also, possibly, to increased light and pleasurable excitement of the senses) is to cause a very marked improvement in digestion, sanguification, and in nervous and muscular vigor.[3] It is inferred that tissue change is accelerated, but nothing definite is known.

The rapid evaporation at elevated positions is certainly a most important element of mountain hygiene. At Puebla and at Mexico the hygrometer of Saussure will often mark 37°, which is equal to only 45 per cent. of saturation,[4] and yet the lower rooms of the houses are very humid, so that, in the town of Mexico, there are really two climates,—one very moist, in the *rez-de-chaussée* of the houses; one very dry, in the upper rooms and the outside air.

The diminution of oxygen, in a certain cubic space, is precisely as the pressure, and can be calculated for any height, if the barometer is noted. Taking dry air only, a cubic foot of air at 30 inches, and at 32° Fahr., contains 130.4 grains of oxygen. An ascent (about 5,000 feet) which reduces the barometer to 25 inches will lessen this $\frac{1}{6}$th, or $\left(\frac{25 + 130.4}{30} = \right)$ 108.6 grains. But it is supposed that the increased number of respirations compensate, or more so, for this; and, in addition, it must be remembered that in experiments on animals, as long as the percentage of oxygen did not sink below a certain point (14 per cent.), as much was absorbed into the blood as when the oxygen was in normal proportion. Jourdanet has indeed asserted[5] that the usual notion that the respirations are augmented in number in the inhabitants of high lands is "completely erroneous;" that the respirations are in fact lessened, and that from time to time a deeper respiration is voluntarily made as a partial compensation. But Coindet, from 1,500 observations on French and Mexicans, does not confirm this; the mean number of respirations was 19.36 per minute for the French, and 20.297 for the Mexicans.

As a curative agent, mountain air (that is, the consequences of lessened pressure chiefly) ranks very high in all anæmic affections from whatever cause (malaria, hemorrhage, digestive feebleness, even lead and mercury poisoning); and it would appear, from Hermann Weber's observations, that the existence of valvular heart disease is, if proper rules are observed, no contradiction against the lower elevations (2,000 to 3,000 feet). Neuralgia, gout, and rheumatism are all benefited by high Alpine positions (H. Weber). Scrofula and consumption have been long known to be rare among the dwellers on high lands, and the curative effect on these diseases of such places is also marked; but it is possible that the open air life which is led

[1] Rattray found an ascent of 2,000 feet (at Ascension) lessened the "vital capacity," as judged of by the spirometer, from 266 to 249 and 243 cubic inches.

[2] Vivenot, Virchow's Archiv, 1860, Band xix., p. 492. This is probable, but not yet proved.

[3] Hermann Weber, Climate of the Swiss Alps, 1864, p. 17.

[4] Jourdanet, Du Mexique, p. 49.

[5] Du Mexique, p. 76.

has an influence, as it is now known that great elevation is not necessary for the cure of phthisis.[1]

Dr. Hermann Weber, in his important work on the Swiss Alps (p. 22), has given the present evidence, and has shown how in the true Alpine region—in Dauphiné, in Peru and Mexico, and in Germany—phthisis is decidedly averted or prevented by high altitudes. The more recent experience of Davos Platz is confirmatory.

Although on the Alps phthisis is arrested in strangers, in many places the Swiss women on the lower heights suffer greatly from it; the cause is a social one; the women employed in making embroidery congregate all day in small, ill-ventilated, low rooms, where they are often obliged to be in a constrained position; their food is poor in quality. Scrofula is very common. The men who live an open-air life are exempt; therefore, in the very place where strangers are getting well of phthisis the natives die from it—another instance that we must look to local conditions and social habits for the great cause of phthisis. If would even seem possible that, after all, it is not indeed elevation and rarefaction of air, but simply plenty of fresh air and exercise, which are the great agents in the cure of phthisis.

Jourdanet, who differs from so much that is commonly accepted on this point, gives additional evidence on the effect of elevation on phthisis. At Vera Cruz phthisis is common; at Puebla and on the Mexican heights, it is almost absent (*á peu près nulle*).

The diseases for which mountain air is least useful are—rheumatism, at the lower elevations where the air is moist; above this rheumatism is improved; and chronic inflammatory affections of the respiratory organs (?). The "mountain asthma" appears, however, from Weber's observations, to be no specific disease, but to be common pulmonary emphysema following chronic bronchitis.

It seems likely that pneumonia, pleurisy, and acute bronchitis are more common in higher Alpine regions than lower down.

Effects of Increased Pressure.—The effects of increased pressure have been noticed in persons working in diving-bells, etc., or in those submitted to treatment by compressed air. (At Lyons and at Reichenhall[2] especially.) When the pressure is increased to from 1¼ to 2 atmospheres, the pulse becomes slower, though this varies in individual cases; the mean lessening is 10 beats per minute; the respirations are slightly lessened (1 per minute); evaporation from the skin and lungs is said to be lessened (?); there is some recession of blood from the peripheral parts; there is a little ringing and sometimes pain in the ears; hearing is more acute; the urine is increased in quantity; appetite is increased; it is said men will work more vigorously. When the pressure is much greater (two or three atmospheres) the effects are sometimes very marked; great lowering of the pulse, heaviness, headache, and sometimes, it is said deafness. It is said[3] that more oxygen is absorbed, and that the venous blood is as red as the arterial; the skin also sometimes acts more, and there may even be sweating. The

[1] Some time ago a remarkable paper was published by Dr. James Blake, of California, on the treatment of phthisis (Pacific Medical Journal, 1860). He adopted the plan of making his patients live in the open air; in the summer months he made them sleep out without any tent; the result was an astonishing improvement in digestion and sanguification; the resistance to any ill effects from cold and wet is described as marvellous. As Dr. Blake is well known to be perfectly trustworthy, these statements are worthy of all consideration.

[2] For an account of the effects noted at Reichenhall, see Dr. Burdon-Sanderson's account in The Practitioner, No. iv., 1868, p. 221.

[3] Foley, "Du Travail dans l'air comprimé," Gaz. Hebdom., 1863, No. 32.

main effect is to lessen the quantity of blood in the veins and auricles, and to increase it in the arteries and ventricles; the filling of the ventricle during the relaxation takes place more slowly. The diastolic interval is lengthened, and the pulse is therefore slower.

When the workmen leave the compressed air they are said to suffer from hemorrhages and occasional nervous affections, which may be from cerebral or spinal hemorrhage.[1] As a curative agent in phthisis, the evidence is unfavorable.

Some observations lately made by M. Bert [2] show that oxygen, when it enters the blood under pressure (such as that given by 17 atmospheres of atmospheric air, or 3½ atmospheres of pure oxygen), is toxic to birds, producing convulsions. Convulsions are produced in dogs when the pressure is only 7 or 8 atmospheres, and when the oxygen amounts to only double the normal amount, or, in other words, reaches 32 C.C. per 100 C.C. of blood. M. Bert conjectures that the toxic influence of oxygen is on the nervous centres, like strychnine. The animal temperature fell 2 or 3 degrees (C.) during the convulsions, so that excess of oxygen did not cause increased combustion. In the case of a dog kept under a pressure of 9½ atmospheres for some time, gas was found in the ventral cavity and in the areolar tissue. In man the pressure of only 5 atmospheres appears to be dangerous.[3]

Is Acclimatization possible?

The doctrine of acclimatization has been much debated, but probably we do not know sufficiently the physiological conditions of the body under different circumstances. In the case of Europeans living till puberty in a temperate region, near the sea-level, and in a moist climate like England, and then going to the tropics, the question of acclimatization would be put in this form,—Does the body accommodate itself to greater heat, to lessened humidity in some cases, or greater in others, and to varying altitudes?

There can be little doubt that the body does accommodate itself within certain limits to greater heat, as we have seen that the lungs act less, the skin more, and that the circulation lessens when Englishmen pass into the tropics. There is so far an accommodation or alteration impressed on the functions of the body by unwonted heat. And we may believe that this effect is permanent, *i.e.*, that the lungs continue to act less, and the skin more, as long as the Europeans remain in the tropics. Doubtless, if the race were perpetuated in the tropics, succeeding generations would show fixed alterations in these organs.

We may conclude that the converse holds true, and that the cold of temperate regions will influence natives of the tropics in an opposite way, and this seems to be rendered likely by the way in which lung affections arise in many of them.

We may admit there is an acclimatization in this sense, but in no other. The usual belief that the constitution acquires in some way a power of

[1] See Limousin, in Canstatt, 1863, Band ii., p. 105, and Babington in Dublin Quarterly Journal, November, 1864.

[2] Chemical News, March 28, 1873.

[3] In the colliery accident at Pont-y-Prydd, several men were confined for ten days in a small space, in which the air was much compressed. The exact pressure is unknown, but it was sufficient to drive one of the men, with fatal force, into the opening made for their rescue. Although the men were without food all the time, they appeared to have suffered less than might have been anticipated.

resisting unhealthy influences—that is, a power of not being any longer susceptible to them—is not supported by any good evidence. The lungs in Europeans will not regain their weight and amount of action in the tropics; a change to a cold climate only will cause this; the skin retains its increased function until the cause producing it is removed. So also there is no acclimatization in any sense of the word for malaria.

SECTION V.

COMPOSITION OF THE AIR.

The proportionate amounts of oxygen and nitrogen remain very constant in all countries, and the range of variation is not great.

So also, apart from the habitations of men, the amount of carbon dioxide is (at elevations occupied by men) constant. The variations in watery vapor have been already noticed.

The only alterations in the composition of the air which come under the head of climate, are changes in the state in which oxygen exists (for no change is known to occur in nitrogen), and the presence of impurities.

SUB-SECTION I.—OZONE.

Ozone is now admitted by most chemists to be an allotropic condition of oxygen; and, as conjectured by Odling, it is now believed that it is a compound molecule made up of three molecules (O_2O) of oxygen. The so-called antozone is now believed to be peroxide of hydrogen diffused in a large quantity of atmospheric air. Variations in the amount of ozone have been supposed to be a cause of climatic difference, but, in spite of all the labor which has been given to this subject, the evidence is very unconclusive. The reaction with the ozone paper is liable to great fallacies.[1] Yet it seems clear that some points are made out; the ozonic reaction is greater in pure than impure air; greater at the seaside than in the interior; greater in mountain air than in the plains; absent in the centre of large towns, yet present in the suburbs; absent in an hospital ward, yet present in the air outside. In this country it is greater with south and west winds; greater, according to Moffat, when the mean daily temperature and the dew-point temperature are above the mean; the same observer found it in increased quantity with decreasing readings of the barometer, and conversely in lessened quantity with increasing readings.

The imperfections in the test render it desirable to avoid drawing conclusions at present; but one or two points must be adverted to.

1. Owing probably to the oxidizing power of ozone when prepared in the laboratory, a great power of destruction of organic matter floating in the air has been ascribed to ozone by Schönbein, and the absence of ozone in the air has been attributed by others to the amount of organic matter in the air of towns. Even the cessation of epidemics (of cholera, malarious fevers) has been ascribed to currents of air bringing ozone with them. The accumulation of malaria at night has been ascribed to the non-production of ozone by the sun's rays (Uhle). The effect of stagnant air in increasing epidemics has also been ascribed to the absence of ozone.

It seems clear that the substance giving the reaction of ozone is neither

[1] The subject of ozone will be found fully discussed by Dr. C. Fox (Ozone and Antozone, 1873). The causes of fallacy in the tests are carefully explained.

deficient in marshy districts, nor when ozone is conducted through marsh dew does it destroy the organic matter.[1]

2. On account of the irritating effect of ozone, when rising from an electrode, Schönbein believed it had the power of causing catarrh, and inferred that epidemics of influenza might be produced by it. He attempted to adduce evidence, but at present it may safely be said that there is no proof of such an origin of epidemic catarrhs.

3. A popular opinion is, that a climate in which there is much ozone (*i.e.*, of the substance giving the reaction with iodide and starch paper) is a healthy, and, to use a common phrase, an exciting one. The coincidence of excess of this reaction with pure air lends some support to this, but, like the former opinions, it still wants a sufficient experimental basis.

On the whole, the subject of the presence and effects of ozone, curious and interesting as it is, is very uncertain at present; experiments must be numerous, and inferences drawn from them must be received with caution.

Sub-Section II.—Malaria.

The most important organic impurity of the atmosphere is malaria, and when a climate is called "unhealthy," in many cases it is simply meant that it is malarious. In the chapters on Soils and Air the most important hygienic facts connected with malaria have been noted. In this place it only remains to note one or two of the climatic points associated with malaria.

1. *Vertical Ascent.*—A marsh or malarious tract of country existing at any point, what altitude gives immunity from the malaria, supposing there is no drifting up ravines? It is well known that even a slight elevation lessens danger—a few feet even, in many cases, but complete security is only obtained at greater heights. Low elevations of 200 to 300 feet are often, indeed, more malarious than lower lands, as if the malaria chiefly floated up.

At present the elevation of perfect security in different parts of the world is not certainly determined, but appears to be—

Italy	400 to 500	feet.[2]
America (Appalachia)	3,000	"
California[3]	1,000	"
India	2,000 to 3,000	"
West Indies	1,400 to 1,800	up to 2,200 feet.

But these numbers are so far uncertain that it has not always been seen that the question is not, whether marshes can exist at these elevations (we know they can be active at 6,000 feet), but whether the emanations from a marsh will ascend that height without drifting up ravines? 1,000 to 1,200 feet would generally give security in all probability.

2. *Horizontal Spread.*—In a calm air Lévy[4] has supposed that the malaria will spread until it occupies a cube of 1,400 to 2,000 feet, which is equivalent to saying it will spread 700 to 1,000 feet horizontally from the central point of the marsh. But currents of air take it great distances, though the best observations show that these distances are less than were

[1] In addition to what has been previously said (Vol. I., p. 131), Grellois has lately stated that he found more ozone over a marsh than elsewhere. An interesting series of observations on ozone in the Bombay Presidency has been made by Dr. Cook.

[2] Carrière, quoted by Lévy, t. i., p. 491.

[3] This information was given Dr. James Blake.

[4] T. i., p. 464.

supposed, and seldom overpass one or two miles, unless the air-currents are rapid and strong. The precise limits are unknown, but it is very doubtful if the belief in transference of malaria by air-currents for 10, 20, or even 100 miles, is correct.

3. *Spread over Water.* — The few precise observations show that this differs in different countries. In the Channel, between Beveland and Walcheren, 3,000 feet of water stopped it (Blane). In China and the West Indies a farther distance is necessary. In China three-quarters of a mile has been effectual;[1] in the West Indies one mile. Grant thinks that salt water is more efficacious than fresh.

SECTION VI.

ELECTRICAL CONDITION—LIGHT.

That these, as well as heat, are important parts of that complex agency we call Climate, seems clear; but little can be said on the point. In hot countries positive electricity is more abundant; but the effect of its amount and variation on health and on the spread and intensity of diseases is quite unknown. All that has been ascribed to it is pure speculation. The only certain fact seems to be that the spread of cholera is not influenced by it.

With regard to light, the physiological doctrine of the necessity of light for growth and perfect nutrition makes us feel sure that this is an important part of climate, but no positive facts are known.

[1] Grant (quoted by Chevers), Indian Annals, 1859, p. 636.

CHAPTER XV.

DESCRIPTION OF THE METEOROLOGICAL INSTRUMENTS, AND A FEW REMARKS ON METEOROLOGY.

As meteorological observations are now so commonly made, and as in the army instruments are provided at many foreign stations, it is desirable to give a few plain instructions on the use of these instruments.[1] For the convenience of beginners, a few observations on Meteorology are also added.

[1] The following is the official circular issued by the Army Medical Department:—

Official Instructions for Reading the Meteorological Instruments.

The observer should make himself thoroughly acquainted with the scale of every instrument, especially with that of the barometer and its attached vernier, and by frequent comparisons ascertain that he and his deputy read the instruments alike, and record the observations accurately.

All observations must be recorded exactly as read. The corrections are to be made only at the end of each month on the "means" of the "sums."

Barometrical observations must be recorded to the third decimal place; thermometrical to the first decimal. When the readings are exactly to the inch or degree, the places for the decimals must be filled up with ciphers.

The observations should be made as quickly as possible, consistent with perfect accuracy, and the observer must avoid breathing on the instruments, particularly the dry and wet bulb, and maximum thermometers.

Barometer Readings.—Note the temperature of attached thermometer in degrees only; by means of the thumb-screw at the bottom adjust the mercury in the cistern to its proper level, the point of the ivory cone, which should just touch the mercury without breaking the surface; then bring the zero line of the vernier to the level of the apex of column of the mercury, and read off in the manner described at pages 15 and 16 of Sir H. James's Book of Instructions.[2]

Thermometer Readings.—The scales are divided to degrees only, but these are so open that the readings can be determined to the tenth of a degree. Practice and attention will insure accuracy.

Maximum Thermometer in Shade.—The maximum thermometer must be hung at such a distance (2 or 3 inches) from the water-vessel of the wet-bulb thermometer, that its readings may not be affected by evaporation.

In hanging the maximum, care must be taken that the end of the tube is *slightly inclined downward*, which will have the effect of assisting in preventing the return of any portion of the column of mercury into the bulb on a decrease of temperature. To read the instrument, gently elevate the end furthest from the bulb to an angle of about 45°, in which position of the instrument note the reading. To re-set the thermometer, a gentle shake or swing, or a tap on the wooden frame of the instrument, will cause the excess of mercury to return to the bulb, and it is again ready for use.

Maximum in Sun's Rays, or the Vacuum Solar Radiation Thermometer.—Being constructed on the same principle as the last-mentioned instrument, it must be read in a similar position. After completing the reading, by giving the instrument a slight

[2] For these are now substituted Instructions in the Use of Meteorological Instruments, by R. H. Scott, M.A., F.R.S., 1877. The Barometer corrections are explained at pp. 30, 31 of that work.

SECTION I.

THERMOMETERS FOR TAKING THE TEMPERATURE OF THE AIR.

Maximum Thermometers.

Two maximum thermometers are issued—one to observe the greatest heat in the sun, the other in the shade.

The *Sun Maximum* or *Solar Radiation Thermometer* is formed by a glass case (from which the air is removed), containing a mercurial thermo-

shake, with the bulb still inclined downward, the excess of mercury will return to the bulb, and the thermometer be ready for the next observation.

Minimum Thermometer in Shade.—The minimum thermometer must be so hung that the bulb may be about *one inch lower* than the other extremity of the instrument, because in this position the index is less likely to be affected by a rise in temperature.

The extremity of the index furthest from the bulb shows the lowest degree to which the spirit has fallen since the last observation. The reading on the scale corresponding to this is the temperature to be recorded. Then by elevating the bulb, the index will float toward the end of the spirit. When it has *nearly arrived at that point*, the instrument is re-set.

Minimum on Grass, Terrestrial Radiation Thermometer is constructed like the last, and the directions above given are also applicable to it.

After reading and re-setting the self-registering thermometers, compare them with the dry-bulb thermometer in order to ascertain that their readings are nearly the same.

Dry and Wet-Bulb Thermometers.—Bring the eye on a level with the top of the mercury in the tube of the dry-bulb thermometer, and take the reading, then complete the observation by noting in like manner the reading of the wet-bulb thermometer.

The temperature of the air is given by the former, that of evaporation by the latter. From these data the hygrometrical results are to be calculated by Glaisher's Tables, 3d edition.[1]

Rain-Gauge and Measure.—Pour the contents of the gauge into any convenient vessel with a lip, and from this into the glass measure, which has been graduated especially for the gauge, and is only to be used in measuring its contents. It is graduated to the hundredths of an inch.

Anemometers.—The dials are read from left to right. The first on the left records hundreds of miles, the second tens, the third miles, the fourth tenths of a mile, and the fifth hundredths of a mile.

The reading of the anemometer is obtained by deducting from the amount registered by the dials the total sum registered at the period of the preceding observation. The difference between those (subject to a small correction) indicates the velocity or horizontal movement of the air in miles during the interval, and must be entered in the return. When the instrument is first set up, the reading on the dials must be noted, in order that it may be deducted from the total registered by the dials at the end of the first period of observation.

In making observations on the presence of ozone, a box has been found to be unnecessary, equally satisfactory results having been obtained by fixing the paper immediately under the penthouse of the stand, which shelters it sufficiently from a strong light, while it secures proper exposure.

The minimum thermometers are liable to get out of order—first, by carriage, when the index may be wholly or partly driven out of the spirit, or a portion of spirit may become detached from the main column; and, secondly, by slow evaporation of the spirit, which rising in the tube, condenses at the upper end. The first-mentioned errors are corrected by taking the thermometer in the hand, with its bulb downward, and giving it a swing up and down. The second is remedied by the inclined position of the instrument, which allows the condensed spirit to trickle back to the main column.[2]

N. B.—On no account whatever is artificial heat to be applied to a spirit thermometer. In re-setting the minimum, the index should never be brought quite to the end of the column of spirit.

[1] A 6th edition is now published.

[2] It is generally necessary to swing the instrument to get back the broken portion of the column.

meter with a blackened bulb. The case shelters from currents of air; the black bulb absorbs the sun's rays. The tube of the thermometer is slightly bent near the bulb, and a piece of porcelain is inserted which narrows the tube. The effect of this is to make the thermometer self-registering, as, after the mercury has expanded to its fullest extent, instead of retiring into the bulb on cooling, it is stopped by the porcelain, and the mercury breaks between the porcelain and the bulb. The instrument is placed at a height of four feet from the ground on wooden supports, and in any place where the sun's rays can freely fall on it.

The *Shade Maximum* is a mercurial thermometer, not inclosed in a case, but mounted on a frame. Its construction and manner of reading are otherwise similar to those of the sun thermometer.

It is placed in the shade four feet above the ground, and sufficiently far from any walls to be unaffected by radiation. It should be freely exposed to the air, but perfectly protected from the sun's rays.

Minimum Thermometers.[1]

Two minimum thermometers are supplied.

The *Shade Minimum* is an alcoholic thermometer with a small index in the alcohol. It is set by allowing the index to slide *nearly* to the end of the spirit; as the spirit contracts during cold, it carries the index down; when it expands again it cannot move the index, but leaves it at the degree of greatest cold. The end of the index farthest from the bulb is the point to read.

This thermometer is placed in the shade four feet above ground, under the same conditions as the *shade maximum*.

The *Grass Minimum* or *Terrestrial Radiation Thermometer* is a thermometer of the same kind, but protected by a glass shield. It is placed almost close to the ground on grass, suspended on little tripods of wood, but it should not touch the ground; it is intended to indicate the amount of cooling produced by radiation from the ground. If snow lies on the ground the bulb should be placed in the snow. Scott recommends a black board on which to lay the thermometer where no grass can be obtained.[2]

Common Thermometer.

The dry bulb of the "wet and dry bulb thermometer" is read as a common thermometer.

Reading of the Thermometers.

All these thermometers can be read to tenths of a degree. The maximum and minimum thermometers are read once a day, usually at 9 A.M.; the former marks the highest point reached on the *previous* afternoon, and must be so entered on the return; the latter, the lowest point reached on the *same* morning.[3] For the army returns the common thermometer is read twice a day, at 9 A.M. and 3 P.M.

[1] Great difficulty is found with spirit thermometers on account of their being so much less sensitive than mercurial. To remedy this the bulb is sometimes made fork-shaped, or otherwise modified so as to expose as large a surface as possible.

[2] Instructions, etc. Scott adds: "Under any circumstances, a board gives a better measure of terrestrial radiation than grass."

[3] It is desirable that these thermometers should be read both morning and evening. In winter the maximum sometimes occurs in the early morning and the minimum in the afternoon. In winter the range depends more on the direction of the wind

Range of the Temperature.—The maximum and minimum in shade give most important climatic indications; the difference between them on the same day constitutes the range of the diurnal fluctuation. The range is expressed in several ways.

The extreme daily range in the month or year is the difference between the maximum and minimum thermometer on any one day.

The extreme monthly or annual range is the difference between the greatest and least height in the month or year.

The mean monthly range is the daily ranges added and divided by the number of days in a month (or between the mean of all the maxima and the mean of all the minima).

The yearly mean range is the monthly ranges added and divided by 12.

Mean Temperature.—The mean temperature of the day is obtained in the following ways:—

(*a*) At Greenwich and other observatories, where by means of photography the height of the thermometer at every moment of the day is registered, the mean of the hourly readings is taken. This has been found to accord with the absolute mean (found by taking the mean of the whole curve) to within $\frac{1}{10}$th of a degree.

(*b*) Approximately in several ways. Taking the mean of the shade maximum and minimum of the same day. In this country, during the cold months (December and January), the result is very close to the truth; but as the temperature increases, a greater and greater error is produced, until in July the mean monthly error is + 1.9° Fahr., and in some hot days is much greater. In the tropics, the mean of the maximum and minimum must give a result still further from the truth.

Monthly corrections can be applied to bring these means nearer the truth. Mr. Glaisher's corrections for this country are as follows:—

Subtract from the monthly mean of the maximum and minimum degrees—

January, 0.2	May, 1.7	September, 1.3
February, 0.4	June, 1.8	October, 1.0
March, 1.0	July, 1.9	November, 0.4
April, 1.5	August, 1.7	December, 0.0

The result is the approximate mean temperature. But this is true only for this country.[1]

In a great number of places the mean temperature of the day and year, as stated in books, is derived solely from the mean of the maximum and minimum.[2] According to Scott, the approximation to the true mean is very close in most parts of the world, especially if the observations be taken as near the *end* of the period as possible, near midnight, for instance, for the mean of the civil day of twenty-four hours.

The approximate mean temperature may also be obtained by taking observations at certain times during the day, and applying a correction.

than on the time of day (Scott). But uniformity of practice is the primary essential, and at stations where observations are made only once a day, viz., at 9 A.M., or even twice, unless the second reading is after 6 P.M., the above rule as to entry must be followed.

[1] These numbers of Mr. Glaisher are likely to be modified very considerably; they are largely dependent on the pattern of the thermometer stand employed.

[2] With a Stevenson screen the simple mean of the maximum and minimum is very near the truth.

Mr. Glaisher has given some very valuable tables of this kind,[1] which can be consulted.[2]

If the temperature be taken twice a day at homonymous hours, such as 9 A.M. and 9 P.M., the mean of these does not differ much from the true daily mean (Scott).

The nearest approach to the mean temperature of the day by a single observation is given at from 8 to 9 P.M.; the next is in the morning—about 8 o'clock in July and 10 in December and January.

The nearest approach to the mean annual temperature is given by the mean of the month of October. Observations made from a week before to a week after April 24th, and again in the corresponding weeks of October, give a certain approximation to the yearly mean temperature.[3]

The changes in temperature of any place, during the day or year, are either periodic or non-periodic. The former are dependent on day and night, and on the seasons, *i.e.*, on the position of the place with respect to the sun. The periodic changes are sometimes termed fluctuations, and the differences between day and night temperatures, or the temperatures of the hottest and coldest months, are often called the amplitudes of the daily or yearly fluctuations.

Daily Periodic Changes.—On land the temperature of the air is usually at its lowest about 3 o'clock A.M., or just before sunrise, and at its maximum about 2 o'clock P.M.; it then falls nearly regularly to 3 o'clock A.M. At sea, the maximum is nearly an hour later.

The amount of diurnal periodic change is greater on land than on water; in the interior of continents than by the sea-side; in elevated districts than at sea-level. As far as land is concerned, it is least on the sea-coast of tropical islands, as at Kingston in Jamaica, Colombo in Ceylon, Singapore, etc.

Yearly Periodic Changes.—In the northern hemisphere, the coldest month is usually January; in some parts of Canada it is February. On the sea, the coldest month is later, viz., March. The hottest month is in most places July, in some few August; on the sea it is always August. The coldest days in this country are toward the 21st January; the hottest, about the 18th to the 21st July. At Toronto the hottest day is 37 days after the summer solstice; and the coldest, 55 days after the winter solstice.

It is thus seen that both for the diurnal and annual alterations of heat the greatest heat is not simultaneous with, but is after, the culmination of the sun; this is owing to the slow absorption of heat by the earth.

The amplitude of the yearly fluctuation is greater on land than sea, and

[1] On the Corrections to be applied to Meteorological Observations for Diurnal Range, prepared by the Council of the British Meteorological Society, 1850. These corrections are applicable only to this country.

[2] The following rules, which are applicable in all parts of the world, are given by Herschel:—[4]

If observations are taken three times daily—at 7 A.M., 2 P.M., and 9 P.M.,—hours which we may denote by t, t', and t''; then

$$\frac{t+t'+2\,t''}{4} = \text{mean temperature of day.}$$

If the hours are 8 A.M., 3 P.M., and 10 P.M., the formula is—

$$\frac{7\,t+7\,t'+10\,t''}{24} = \text{mean of day.}$$

[3] Herschel, Meteorology, p. 180.

[4] Meteorology, p. 173.

is augmented by land, so that it reaches its highest point in the interior of great extra-tropical continents.

It increases toward the pole for three reasons,—

1. The geographical fluctuation of the earth's position causes a great yearly difference of the angle with which the sun's rays fall on the earth.

2. The duration of incidence of the sun's rays (i.e., the number of hours of sunshine or shade) have greater yearly differences than in the tropics.

3. In the northern hemisphere especially there is a very great extent of land, which increases radiation.

The amplitude of the yearly fluctuation is very small in the tropical lands at sea-level. At Singapore, it is only 3.6° Fahr. (January 78°, July 82.4°), while it is immense on continents near the pole. At Jakoutsk, in North Asia, it is 112.5° (January − 44.5° and July + 68). All fluctuations depend to a large extent upon the distance from the sea, although local causes may have some influence, such as the vicinity of high lands.

In any place there may be great undulations and small fluctuations, or great changes in each way. At Brussels, the greatest possible yearly undulation is 90°. In some parts of Canada, immense undulations sometimes occur in a day, the thermometer ranging even 50° to 70° in one day.

The hot winds of the rainless deserts have long puzzled meteorologists; they often cause enormous undulations, 50° to as much as 78° Fahr.

Temperature of the Air of any Place.

This depends on the following conditions:—

1. *Geographical Position as influencing the Amount and Duration of Sun's Rays which are received.*—The nearer the equator the hotter. For 23½° on either side the equator the sun's rays are vertical twice in the year, and are never more oblique than 47°. The mean yearly temperature of the equator is 82° Fahr.; of the pole about 2.5° Fahr. The decline from the equator to the pole is not regular; it is more rapid from the equator to 30° than in the higher latitudes.

2. *Relative Amount of Land and Water.*—The sun's rays passing through the air with but trifling loss fall on land or on water. The specific heat of land being only one quarter that of water, it both absorbs heat and gives it out more rapidly. Water, on the other hand, absorbs it more slowly, stores up a greater quantity, and parts with it less readily. The temperature of the superficial water, even in the hottest regions, seldom exceeds 80° to 82°, and that of the air is generally below (2° to even 6°) the temperature of the water (J. Davy). Consequently the more land the greater is the heat, and the wider the diurnal and yearly amplitudes of fluctuation. The kind of soil has a great effect on absorption. The evaporation from the water also greatly cools the air.

3. *Elevation of the Place above the Sea-level.*—The greater the elevation the colder the air, on account—1st, of the lessening amount of earth to absorb the sun's rays; and, 2d, on account of the greater radiation into free space. The decline of temperature used to be reckoned at about 1° Fahr. for each 300 feet of ascent, but the balloon ascents of Mr. Welsh, and especially of Mr. Glaisher, have proved that there is no regular decline; there are many currents of warm air even in the upper atmosphere. Still the old rule is useful as an approximation. The amount of decline varies, however, in the same place at different times of the year. In Mr. Glaisher's balloon ascents, in a *cloudy* sky, it was about 4° Fahr. for each inch of

barometric fall, at first; but when the barometer had fallen 11 inches, the decline of temperature was more rapid. Under a *clear* sky there was a fall of 5° Fahr. for each of the first four inches of descent; then 4° per inch till the thirteenth inch of descent, and then 4.5° for fourteenth, fifteenth, and sixteenth inches of descent.

The snow-line at any spot, or the height at which snow will lie the whole year, can be approximately reckoned by taking the mean yearly temperature of the latitude at sea-level, and multiplying the difference between that temperature and 32° Fahr. by 300. The aspect of a place, however, the distance from the sea, and other circumstances, have much to do with the height of the permanent snow-line. The mean temperature of any place can be approximately reckoned in the same way, if the mean temperature of the latitude at sea-level, and the elevation of the place in feet, be known.

4. *Aspect and Exposure, and Special Local Conditions.*—These circumstances chiefly affect a place by allowing free exposure to, or sheltering from the sun's rays, therefore lessening the number of hours the rays reach the soil, or by furnishing at certain times a large moist surface. Thus the extensive sandbanks of the Mersey cause very rapid alterations of temperature in the water and air, by being exposed every twenty-four hours twice to the sun and sky (Adie).

5. *Aërial and Ocean Currents.*—These have a great effect, bringing clouds which block out the sun or produce rain, or which, in the case of ocean currents, cool or warm the air. The cold polar sea currents and the warm equatorial (like the Gulf Stream) in some cases almost determine, and always greatly influence, the temperature of a place.

6. *Nature of the Soil.*—On this point little is yet known, but it is certain that some soils easily absorb heat; others do not. The moist and clayey soils are cold; the dry hard rocks and dry sands are hot.

The hottest places on the earth are—in the eastern hemisphere, near the Red Sea, at Massava and Khartoum (15° N. L.), and on the Nile, in Lower Nubia; annual temperature = 90.5° Fahr.; in the western hemisphere, on the Continent, near the West Indies, the annual temperature is 81.5°. These are sometimes called the climatic poles of heat. The poles of cold are in Siberia (Jakoutsk to Usjausk, 62° N.), and near Melville Island.

Isothermal Lines.—These are lines drawn on charts, and were proposed by Humboldt to connect all places having the same mean annual temperature. The various conditions just noted cause these lines to deviate more or less from the lines of latitude.

The lines of mean summer temperature (three months, June, July, August) are sometimes called *isotheral;* those of mean winter temperature (December, January, and February) *isocheimonal*, or *isocheimal*, but these terms are now seldom used, the terms summer, winter, or monthly isothermal, being substituted.[1]

[1] It may be well to mention the relations between the three principal thermometer scales. Whilst the freezing-point in the Fahrenheit scale is at 32°, it is at 0° in both the Centigrade (or Celsius) and the Réaumur scales. Water boils at 212° on the Fahrenheit scale (barometer = 29.905), at 100° on the Centigrade, and at 80° of Réaumur.

Hence the formula of reduction is:—

$$\frac{F-32}{9} = \frac{C}{5} = \frac{R}{4},$$

from which the corresponding temperatures can easily be found.

SECTION II.

HYGROMETERS—HUMIDITY OF THE AIR.

The amount of watery vapor in the air can be determined in several ways; by direct weighing, by Daniell's, Regnault's or Dines' hygrometer, by the hair hygrometers of Saussure and Wolpert, and by the dry and wet bulbs.[1] The method by the dry and wet bulb thermometers has been adopted by the Army Medical Department, and observations are taken twice daily (9 A.M. and 3 P.M.). The instruments are not self-registering, and are simply read off. They are placed in the shade, four feet above the ground, the bulbs freely exposed to the air, but not exposed to the effect of radiant heat from brick walls, etc. The wet bulb is covered with muslin, which is kept moistened by cotton twisted round the bulb and then passing into the water-vessel; previous to use, the cotton is soaked in solution of carbonate of soda, or boiled in ether to free it from fat, so that water may ascend easily in it by capillary attraction; the muslin and cotton should be renewed frequently, once or twice a month if possible; the water must be either rain or distilled water, and the supply ought to be more ample in dry hot weather than in damp. When the temperature is below the freezing-point, the passage of water along the cotton is arrested; it is then necessary to moisten the wet bulb some time before the hour of observation so as to allow the moisture to freeze. The *dew-point*, the *weight of a cubic foot of vapor*, and the *relative humidity*, are to be computed from Mr. Glaisher's tables.[2]

Definition of these Terms.—The *dew-point* is the temperature when the air is just saturated with moisture, so that the least cooling would cause a deposit of water. The quantity of vapor which can be taken up and be made quite invisible to the senses varies with temperature, and is called the *weight of a cubic foot of vapor*, or, less accurately, the *weight of vapor in a cubic foot of air*, at the particular temperature.

The dew-point may be obtained *directly* by Daniell's or Regnault's or Dines' hygrometer, which enable us to cool and note the temperature of a bright surface until the dew is deposited on it, or *indirectly* by means of the dry and wet bulbs.

Unless the air is saturated, the temperature of the wet bulb (*i.e.*, the temperature of evaporation) is always above the dew-point, but is below the temperature of the dry bulb, being reduced by the evaporation. If the dry and wet bulbs are of the same temperature, the air is saturated with moisture, and the temperature noted is the dew-point; if they are not of the same temperature, the dew-point is at some distance below the wet bulb temperature.[3]

It can then be calculated out in two ways.

(*a*) By Mr. Glaisher's factors.—By comparison of the result of Daniell's hygrometer and the dry and wet bulb thermometers for a long term of years, Mr. Glaisher has deduced an empirical formula, which is thus

[1] These last are to be considered as one instrument, and are frequently called the Psychrometer of August, or (in this country) of Mason.

[2] Hygrometrical Tables, 6th edition, 1877. A copy is now sent to each station.

[3] Occasionally the wet bulb may read higher than the dry, as in thick fog or during very calm, cold weather. This is rare, but, should it be met with, then the temperature of the dry bulb is to be taken and considered to be at saturation (Scott).

worked. Take the difference of the dry and wet bulb, and multiply it by the factor which stands opposite the *dry bulb* temperature in the following table, deduct the product from the *dry bulb* temperature, the result is the dew-point. From this formula Glaisher's tables are calculated.

Glaisher's Factors.

Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.
°		°		°		°	
10	8·78	33	3·01	56	1·94	79	1·69
11	8·78	34	2·77	57	1·92	80	1·68
12	8·78	35	2·60	58	1·90	81	1·68
13	8·77	36	2·50	59	1·89	82	1·67
14	8·76	37	2·42	60	1·88	83	1·67
15	8·75	38	2·36	61	1·87	84	1·66
16	8·70	39	2·32	62	1·86	85	1·65
17	8·62	40	2·29	63	1·85	86	1·65
18	8·50	41	2·26	64	1·83	87	1·64
19	8·34	42	2·23	65	1·82	88	1·64
20	8·14	43	2·20	66	1·81	89	1·63
21	7·88	44	2·18	67	1·80	90	1·63
22	7·60	45	2·16	68	1·79	91	1·62
23	7·28	46	2·14	69	1·78	92	1·62
24	6·92	47	2·12	70	1·77	93	1·61
25	6·53	48	2·10	71	1·76	94	1·60
26	6·08	49	2·08	72	1·75	95	1·60
27	5·61	50	2·06	73	1·74	96	1·59
28	5·12	51	2·04	74	1·73	97	1·59
29	4·63	52	2·02	75	1·72	98	1·58
30	4·15	53	2·00	76	1·71	99	1·58
31	3·60	54	1·98	77	1·70	100	1·57
32	3·32	55	1·96	78	1·69		

(*b*) *Apjohn's Formula.*—From a most philosophical and exhaustive analysis of the conditions of this complicated problem, Dr. Apjohn has derived his celebrated formula, which is now in general use. Reduced to its most simple expression, it is thus worked:—A table of the elastic tension of vapor, in inches of mercury at different temperatures, must be used. From this table take out the elastic tension of the temperature of the *wet* thermometer, and call it f'. Let $(t-t')$ be the difference of the two thermometers, and p the observed height of the barometer. Apjohn's formula then enables us to calculate the elastic tension of the dew-point, which we will call f''; and this being known by looking in the table, we obtain, opposite this elastic tension, the dew-point temperature.

The formula is:

$$f'' = f' - 0.01147\ (t-t')\frac{p-f'}{30}.$$

The fraction $\frac{p-f'}{30}$ differs but little from unity, and may be neglected; the formula then becomes, for the temperature above 32° Fahr.:

$$f'' = f' - \frac{(t-t')}{87}.$$

If below 32° the formula is: $f'' = f' - \frac{(t-t')}{96}$.

The *dew-point* being known, the *weight of a cubic foot of vapor*, and the amount of *elastic tension*, expressed in inches of mercury (if this is desired), are taken from tables; the *relative humidity* is got by calculation.

The *relative humidity* is merely a convenient term to express comparative dryness or moisture. Complete saturation being assumed to be 100, any degree of dryness may be expressed as a percentage of this, and is obtained at once by dividing the weight of vapor actually existing by the weight of vapor which would have been present had the air been saturated.

In order to save trouble, all these points, and other matters of interest, such as the weight of a cubic foot of dry air, or of mixed dry and moist air, are given in Mr. Glaisher's "Hygrometrical Tables," which all medical officers are advised to get.

The amount of watery vapor can also be told by a hair hygrometer. A modification of Saussure's hygrometer is still used in France, and also in Russia and Norway. A human hair, freed from fat by digestion in liquor potassæ or ether, is stretched between a fixed point and a small needle, which traverses a scale divided into 100 parts. As the hair shortens or elongates the needle moves and indicates the relative humidity.[1] The scale is graduated by wetting the hair for complete saturation, and by placing it over sulphuric acid of known strength for fifteen degrees of saturation.[2] A very delicate instrument is thus obtained, which indicates even momentary changes in moisture. On comparison with the wet and dry bulb, it has been found to give accordant results for three or four months; it then gradually stretches, and requires to be a little wound up. If compared with the dry and wet bulb, the hair hygrometer seems to be exact enough for experiments in ventilation, for which it is adapted from its rapidity of indication. It has also been recommended by the Vienna congress for use in extreme climates, when the indications of the psychrometer are either uncertain or entirely astray.[3] The horse-hair hygrometer of Wolpert is also much used in Germany.

The amount of watery vapor in the air has a considerable effect on the temperature of a place. Hermann von Schlagintweit[4] has pointed out that the differences between the temperature marked in the sun and shade by two maximum thermometers are chiefly dependent on the amount of humidity. The maxima of insolation (measured by the difference between the sun and shade thermometers) occur in those stations and on those days when humidity is greatest. Thus, at Calcutta, the relative humidity being 80 to 93, the insolation (or difference between the thermometers) is 50° Fahr.; at Bellary the relative humidity being 60 to 65, the insolation is 8° to 11°. These results are explained by Tyndall's observations, which show that the transparent humidity will scarcely affect the sun's rays striking on the sun thermometer, while it greatly obstructs the radiation of invisible heat from the thermometer; when the air is highly charged with moisture, the sun thermometer is constantly gaining heat from the sun's rays, while it loses little by radiation, or if it does lose by radiation, gains it again from the air.

When watery vapor mixes with dry air, the volume of the latter is aug-

[1] Hair shortens when dry, and elongates when moist.
[2] The graduation of the scale is explained in The Arctic Manual, p. 16.
[3] See Scott's Instructions, p. 47.
[4] Proceedings of the Royal Society, vol. xiv., p. 111, 1865.

mented; the weight of a cubic foot of dry air at 60° Fahr. is 536.28 grains, and that of a cubic foot of vapor at 60° is 5.77 grains; the conjoint weights would be 542.05 grains at 60°, but, owing to the enlargement of the air, the actual weight of a cubic foot of saturated air at 60° is only 532.84 grains.

SECTION III.

BAROMETER.

A good mercurial barometer is supplied to many army stations; the scale is brass, graduated on the scale to 20ths or half-tenths, and is read to $\frac{2}{1000}$ths by means of a vernier. There is a movable bottom to the cistern, which is worked up and down by a screw, so as to keep the mercury in the cistern at the same level. Correction for capacity is thus avoided.

To fix the Barometer.—Choose a place with a good light, yet protected from direct sunlight and rain; fix the frame sent with the barometer very carefully with a plumb-line, so as to have it exactly perpendicular; then hang the barometer on the hook, and adjust it gently by means of the three screws at the bottom, so that it hangs truly in the centre. Test this by the plumb-line (a 4 oz. weight tied to a string will do), and then unscrew the bottom of the cistern till the ivory point is seen.

Before fixing the barometer the bottom should be unscrewed till the mercury is two or three inches from the top; the barometer should be rather suddenly inclined, so as to let the mercury strike against the top; if there is no air it will do this with a sharp click; if there be air there is no click; in that case turn the barometer upside down, and tap the side forcibly till you see the globule of air passing up the tube through the mercury into the cistern. Do not be afraid of doing this; there is no danger of any damage to the instrument.

Reading of Barometer.—Read the attached thermometer first; then adjust the cistern, so that the ivory point, perceptible through the glass wall of the cistern, seems just to touch the point of the image in the mercury. Then adjust the vernier, so as to cut off the light from the *top* of the mercury. Then read the scale with the help of the vernier.

A little difficulty is sometimes experienced, by those who are not accustomed to such instruments, in understanding the vernier. It will be, probably, comprehended from a little description, read with the instrument before us. On the scale of the barometer itself, it will be seen that the smallest divisions correspond to half-tenths; that is, to $\frac{5}{100}$ths of an inch (=.05). The height of the mercury can be read thus far on the scale itself. The vernier is intended to enable us to read the amount of space the top of the mercury is above or below one of these half-tenth lines. It will be observed that the vernier is divided into twenty-five lines; but on adjusting it, so that its lower line corresponds with a line indicating an inch, it will be seen that its twenty-five divisions only equal twenty-four half-tenth divisions on the scale. The result is, that each division on the vernier is $\frac{1}{25}$th less than a half-tenth division on the scale. One $\frac{1}{25}$th of a half-tenth is $\frac{2}{1000}$ths of an inch (.05÷25=.002 inch). This being understood, adjust the vernier so that its *lowest* line accurately corresponds to any line on the scale. It will then be seen that its lowest line but one is a little distance below (in fact, .002 inch) the next line on the fixed scale.

Raise now the vernier, so that its second line shall correspond to the line on the scale to which it was a little below; and of course the bottom of the vernier must be raised .002 inch above the line it first corresponded with. If the next line, the third on the vernier, be made to correspond with the line on the scale just above it, the bottom of the scale must be raised double this (.004 inch) above the line it was first level with; if the next line on the vernier be made to correspond with a line on the scale, the scale is raised .006, and so on. Each division on the vernier equals .002 inch, and each five divisions equals $\frac{1}{100}$th, or .01 inch.

The barometer is read thus. The vernier being adjusted to the top of the mercury, read on the *scale* to the half-tenth; then look above, and see what line on the *vernier* corresponds exactly to a line on the scale. Then read the number on the vernier, counting from the bottom; multiply by .002, and the result is the number of thousandths of an inch the top of the mercury is above the half-tenth line next below it.[1] Add this number to that already got by direct reading of the fixed scale, and the result is the height of the mercury in inches and decimals of an inch.

Corrections for the Barometer.—The barometer supplied to military stations requires no corrections for capacity. There are two constant corrections for all barometers, viz., capillarity and index error. The first depends on the size of the bore, and whether the mercury has been boiled in the tube or not. Index error is determined by comparison with a standard barometer. The index and capillarity errors are put together. The capillarity error is always additive; the index error may be subtractive or additive, but the two together form a constant quantity, and the certificates furnished by the Kew Observatory, for all barometers verified there, include both corrections above mentioned.

Corrections for Temperature.—The barometer readings are, to facilitate comparison, always reduced to what they would have been were both scale and mercury at 32° F. If the temperature of the mercury be above this, the metal expands, and reads higher than it would do at 32°. The amount of expansion of mercury is .0001001 of its bulk for each degree; but the linear expansion of the brass scale must be also considered.

Schumacher's formula is used for the correction—viz.,

h = observed height of barometer in inches.

t = temperature of attached thermometer (Fahr.).

m = expansion of mercury per degree—viz., .0001001 of its length at 32°.

s = linear expansion of scale—viz., .00001041; normal temperature being 62°.

$$-h\,\frac{m\ (t-32°)-s\ (t-62°)}{1+m\ (t-32°)}.$$

To facilitate the correction for temperature, tables are given in Mr. R.

[1] Instead of multiplying the number on the vernier by .002, a little practice will enable the calculation to be made at once. On the vernier will be seen the figures 1, 2, 3, 4, and 5; corresponding to the 5th, 10th, 15th, 20th, and 25th lines, and indicating .01, .02, .03, .04, or .05 inch. Each line between these numbered lines equals .002 inch.

H. Scott's "Instructions in the Use of Meteorological Instruments," which is distributed to medical officers.

Correction for Altitude above Sea-level.—As the mercury falls about $\frac{1}{1000}$ (.001 inch)[1] for every foot of ascent, this amount multiplied by the number of feet must be added to the height, if the place be above sea-level.[2] The temperature of the air has, however, also to be taken into account if great accuracy is required. Tables for correcting for small altitudes are given in Scott's "Instructions."

When all these corrections have been made, the exact height of the mercury represents the conjoint weights of the oxygen, nitrogen, carbon dioxide, and watery vapor of the atmosphere. It is difficult to separate these several weights, and late observations, which show that the humidity existing at any place is merely local, and that vapor is most unequally diffused through the air, render it quite uncertain what amount of the mercury is supported by the watery vapor. Yet that this has a considerable effect in altering the barometric height, particularly in the tropics, seems certain (Herschel).

The height of the barometer at sea-level differs at different parts of the earth's surface; being less at the equator (29.974) than on either side of 30° N. and S. lat., and lessening again toward the poles, especially toward the south, from 63° to 74° S. lat., where the depression is upward of an inch. It also differs in different places according to their geographical position. Like the thermometer, it is subjected to diurnal and annual periodic changes and to non-periodic undulations.

In the tropics the diurnal changes are very steady; there are two maxima and two minima; the first maximum is about 9 A.M.; the first minimum about 3 to 4 P.M.; the second maximum at 10 P.M.; the second minimum at 4 A.M. These changes are, perhaps, chiefly dependent on the watery vapor (Herschel). In this country the diurnal range is less, but occurs at about the same hours. The undulations depend on the constantly shifting currents of air, rendering the total amount of air over a place heavier or lighter. The wind tends to pass toward the locality of least barometric pressure. In this country the barometer falls with the southwest winds; rises with the north and east; the former are moist and warm, the latter dry and cold winds.

Isobarometric lines are lines connecting places with the same barometric pressure.

Measurement of Heights.—The barometer falls when heights are ascended, as a certain weight of air is left below it. The diminution is not uniform, for the higher the ascent the less weighty the air, and a greater and greater height must be ascended to depress the barometer one inch. This is illustrated by the following table:[3]

[1] The exact amount is a little below this, but varies with altitude; at sea-level the amount is .000886 for every foot of ascent.

[2] For the British Isles, the mean sea-level at Liverpool has been selected by the Ordnance Survey as their datum.

[3] The height can be taken readily from this table, by calculating the number of feet which must have been ascended to cause the observed fall, and then making a correction for temperature, by multiplying the number obtained from the table, which may be called A, by the formula (t is the temperature of the lower, and t' of the upper station)—

$$\left(1 + \frac{t+t'-64}{900}\right) \times A.$$

To lower from	31	inches to	30 =	857	feet must be ascended.
"	30	"	29 =	886	" "
"	29	"	28 =	918	" "
"	28	"	27 =	951	" "
"	27	"	26 =	986	" "
"	26	"	25 =	1,025	" "
"	25	"	24 =	1,068	" "
"	24	"	23 =	1,113	" "
"	23	"	22 =	1,161	" "
"	22	"	21 =	1,216	" "
"	21	"	20 =	1,276	" "
"	20	"	19 =	1,341	" "
"	19	"	18 =	1,413	" "

The measurements of heights in this way is of great use to medical officers; aneroid barometers can be used, and are very delicate instruments. The new pocket aneroids will measure up to 12,000 or 14,000 feet.

A great number of methods are in use for calculating heights. It can be done readily by logarithms, but then a medical officer may not possess a table of logarithms.

The simplest rule of all is one derived from Laplace's formula. Mr. Ellis[1] has stated this formula as follows:—Multiply the difference of the barometric readings by 52,400, and divide by the sum of the barometric readings. If the result be 1,000, 2,000, 3,000, 4,000, or 5,000, add 0, 0, 2, 6, 14, respectively. Subtract $2\frac{1}{3}$ times the difference of the temperatures of the mercury. Multiply the remainder by a number obtained by adding 836 to the sum of the temperatures of the air, and dividing by 900. A correction must also be made for latitude, which can be done by Table III., p. 111.

Tables such as those given by Delcros and Oltmanns are very convenient for estimating heights by the barometer. A table less long than these, but based on the same principle, has been given by Negretti & Zambra in their useful work,[2] and is copied here.

A good mercurial barometer, with an attached thermometer, or an aneroid compensated for temperature, and a thermometer to ascertain the temperature of the air, are required. Two barometers and two thermometers, which can be observed at the same moment at the upper and lower stations, are desirable.

Supposing, however, there is but one barometer, take the height at the lower station, and correct for temperature to 32°. Take the temperature of the air. Ascend as rapidly as possible to the upper station, and take the height of the barometer (correcting it to 32°) and the temperature of the air; then use the accompanying tables, taken from Negretti & Zambra's work. If the height is less than 300 feet, Tables II., III., and IV. need not be used.

"Table I. is calculated from the formula, height in feet = 60,200 (log. 29.922—log. B)+925; where 29.922 is the mean atmospheric pressure at 32° Fahr., and at the mean sea-level in latitude 45°; and B is any other barometric pressure; the 925 being added to avoid *minus* signs in the table.

[1] Proceedings of the Royal Society, 1865, No. 75, p. 283.
[2] A Treatise on Meteorological Instruments, by Negretti & Zambra, 1864.

TABLE I.—*Approximate Height due to Barometric Pressure.*

Inches of Barometer.	Feet.	Inches of Barometer.	Feet.	Inches of Barometer.	Feet.
31·0	0	27·3	3,323	23·6	7,131
30·9	84	·2	3,419	·5	7,242
·8	169	·1	3,515	·4	7,353
·7	254	27·0	3,612	·3	7,465
·6	339	26·9	3,709	·2	7,577
·5	425	·8	3,806	·1	7,690
·4	511	·7	3,904	23·0	7,803
·3	597	·6	4,002	22·9	7,917
·2	683	·5	4,100	·8	8,032
·1	770	·4	4,199	·7	8,147
30·0	857	·3	4,298	·6	8,262
29·9	944	·2	4,398	·5	8,378
·8	1,032	·1	4,498	·4	8,495
·7	1,120	26·0	4,588	·3	8,612
·6	1,208	25·9	4,699	·2	8,729
·5	1,296	·8	4,800	·1	8,847
·4	1,385	·7	4,902	22·0	9,966
·3	1,474	·6	5,004	21·9	9,085
·2	1,563	·5	5,106	·8	9,205
·1	1,653	·4	5,209	·7	9,325
29·0	1,743	·3	5,312	·6	9,446
28·9	1,833	·2	5,415	·5	9,567
·8	1,924	·1	5,519	·4	9,689
·7	2,015	25·0	5,623	·3	9,811
·6	2,016	24·9	5,728	·2	9,934
·5	2,198	·8	5,833	·1	10,058
·4	2,290	·7	5,939	21·0	10,182
·3	2,382	·6	6,045	20·9	10,307
·2	2,475	·5	6,152	·8	10,432
·1	2,568	·4	6,259	·7	10,558
28·0	2,661	·3	6,366	·6	10,684
27·9	2,754	·2	6,474	·5	10,812
·8	2,848	·1	6,582	·4	10,940
·7	2,942	24·0	9,691	·3	11,069
·6	3,037	23·9	6,800	·2	11,198
·5	3,132	·8	6,910	·1	11,328
27·4	3,227	23·7	7,020	20·0	11,458

"Table II. contains the correction necessary for the mean temperature of the stratum of air between the stations of observation; and is computed from Regnault's co-efficient for the expansion of air, which is .002036 of its volume at 32° for each degree above that temperature.

"Table III. is the correction due to the difference of gravitation in any other latitude, and is found from the formula, $x = 1 + .00265 \cos. 2 \text{ lat.}$

"Table IV. is to correct for the diminution of gravity in ascending from the sea-level.

"To use these tables: The barometer readings at the upper and lower stations having been corrected and reduced to temperature 32° Fahr., take out from Table I. the numbers opposite the corrected readings of the two barometers, and subtract the lower from the upper. Multiply this difference successively by the factors found in Tables II. and III. The factor from Table III. may be neglected unless great precision is desired. Finally, add the correction taken from Table IV." (Negretti & Zambra.)

In the table the barometer is only read to 10ths, but it should be read

to 100ths (.01) and 1,000ths (.001), and the number of feet corresponding to these amounts calculated from the table, which is easy enough.

TABLE II.—*Correction due to Mean Temperatures of the Air; the Temperature of the Upper and Lower Stations being added and divided by 2.*

Mean Temp.	Factor.	Mean Temp.	Factor.	Mean Temp.	Factor.
10°	0·955	35°	1·006	60°	1·057
11	·957	36	1·008	61	1·059
12	·959	37	1·010	62	1·061
13	·961	38	1·012	63	1·063
14	·963	39	1·014	64	1·065
15	·965	40	1·016	65	1·067
16	·967	41	1·018	66	1·069
17	·969	42	1·020	67	1·071
18	·971	43	1·022	68	1·073
19	·974	44	1·024	69	1·075
20	·976	45	1·026	70	1·077
21	·978	46	1·029	71	1·079
22	·980	47	1·031	72	1·081
23	·982	48	1·033	73	1·083
24	·984	49	1·035	74	1·086
25	·986	50	1·037	75	1·088
26	·988	51	1·039	76	1·090
27	·990	52	1·041	77	1·092
28	·992	53	1·043	78	1·094
29	·994	54	1·045	79	1·096
30	·996	55	1·047	80	1·098
31	0·998	56	1·049	81	1·100
32	1·000	57	1·051	82	1·102
33	1·002	58	1·053	83	1·104
34	1·004	59	1·055	84	1·106

TABLE III.—*Correction due to Difference of Gravitation in different Latitudes.*

Latitude.	Factor.	Latitude.	Factor.	Latitude.	Factor.
80°	0·99751	50°	0·99954	20°	1·00203
75	0·99770	45	1·00000	15	1·00230
70	0·99797	40	1·00046	10	1·00249
65	0·99830	35	1·00090	5	1·00261
60	0·99868	30	1·00132	0	1·00265
55	0·99910	25	1·00170		

TABLE IV.

Height in Thousand Feet.	Correction Additive.	Height in Thousand Feet.	Correction Additive.
1	3	9	26
2	5	10	30
3	8	11	33
4	11	12	37
5	14	13	41
6	17	14	44
7	20	15	48
8	23		

Example.—At two stations the barometer read respectively 29.9 and 21.2, the temperatures of the air being 60° and 40°.

Barometer at upper station	21.2, Table I.	9,934
" lower "	29.9, "	944
Approximate mean height		8,990
Mean temperature 50°, Table II., Factor		1.037
Height corrected for temperature		9,323
Latitude (say) 30°, Table III., Factor		1.00132
Height corrected for latitude		9,335
Correction from Table IV.		26
Height corrected for direct altitude		9,361
Height of lower station above sea-level (say)		150
Final corrected height of upper station above sea-level.		9,511

A very simple rule for approximative determinations has been given by Mr. R. Strahan.[1] Read the aneroid to the nearest hundredth of an inch; subtract the upper reading from the lower, leaving out or neglecting the decimal point; multiply the difference by 9; the product is the elevation in feet.

Example.

	inches.
Lower station	30.25
Upper "	29.02
	123
	9
Elevation	1,170 feet.

If the barometer at the upper station is below 26 inches, or the temperature above 70°, the multiplier should be 10.

Weight of the Air.—The barometer expresses the weight of the air in inches of mercury. The actual weight can be determined if the reading of the barometer, temperature, and humidity are all known.

The weight of a cubic foot of dry air, at 32° Fahr. and normal pressure, is 566.85 grains. For any other temperature the weight can be calculated. Multiply the coefficient of the expansion of air (viz., .0020361 for 1° Fahr.) by the number of degrees above 32, the sum added to unity will give the volume of a cubic foot of dry air at that temperature. Divide 566.85 by the number so obtained. The result is the weight of the dry air at the given temperature.

SECTION IV.

RAIN.

Rain is estimated in inches; that is, the fall of an inch of rain implies that on any given area, say a square yard of surface, rain has fallen equal to one inch in depth. The amount of rain is determined by a rain-gauge.

[1] Pocket Altitude Tables, by G. J. Symons, F.R.S., 3d ed., 1880, p. 5.

Two gauges are supplied for military stations; one to be placed on the ground, one 20 feet above it; in all parts of the world the latter indicates less rain than the lower placed gauge; this is due to wind.[1]

Several kinds of gauges are in use. The one used by the Army Medical Department is a cylindrical tin box with a rim or groove at the top; a circular top with a funnel inside fits on to this groove, which, when filled with water, forms a water-valve. The opening above is circular (the circle being made very carefully, and a rim being carried round it to prevent the rain-drops from being whirled by wind out of the mouth), and descends funnel-shaped, the small end of the funnel being turned up to prevent evaporation. But leaves, dust, or insects sometimes choke this tube, so that it is now generally straightened, the loss by evaporation being insignificant, compared with that caused by obstruction. The best size for the open top, or, in other words, the area of the receiving surface, is from 50 to 100 square inches. The lower part of the box is sunk in the ground nearly to the groove; the upper part is then put on, and a glass vessel is placed below the funnel to receive the water.[2] At stated times (usually at 9 A.M. daily) the top is taken off, the glass vessel taken out, and the water measured in a glass vessel, graduated to hundredths of an inch, which is sent with the gauge.[3]

If snow falls instead of rain, it must be melted and the resulting water measured. This may be easily done by adding a measured quantity of warm water, and then subtracting the amount from the total bulk of water.

From a table of the weight of vapor it will be seen that the amount of vapor which can be rendered insensible, increases with the temperature, but not regularly; more, comparatively, is taken up by the high temperatures; thus, at 40°, 2.86 grains are supported; at 50°, 4.10 grains, or 1.24 grain more; at 60°, 5.77 grains, or 1.67 grain more than at 50°. Therefore, if two currents of air of unequal temperatures, but equally saturated with moisture, meet in equal volume, the temperature will be the mean of the two, but the amount of vapor which will be kept invisible is less than

[1] See British Rainfall (G. J. Symons, F.R.S.), 1872, p. 33, and 1881, p. 41.

[2] A glass vessel should not be used in winter, for fear of breakage in frost.

[3] If this glass is broken it can be replaced by the following rule, or a rain-gauge can be made. It need not be round, though this is now thought the best form, but may be a square box of metal or wood, and may be of any size between 3 and 24 inches in diameter, but 5 to 8 is the most convenient range.

Determine the area, in square inches, of the receiving surface, or top of the gauge, by careful measurement. This area, if covered with water to the height of one inch, would give us a corresponding amount of cubic inches. This number of cubic inches is the measure for that gauge of one inch, because when the rain equals that quantity it shows that one inch of rain has fallen over the whole surface.

Let us say the area of the receiving surface is 100 square inches. Take 100 cubic inches of water and put it into a glass, put a mark at the height of the fluid, and divide the glass below it into 100 equal parts. If the rainfall comes up to the mark, one inch of rain has fallen on each square inch of surface; if it only comes up to a mark below, some amount less than an inch (which is so expressed in $\frac{1}{10}$ths and $\frac{1}{100}$ths) has fallen.

To get the requisite number of cubic inches of water we can weigh or measure. A cubic inch of water at 62° weighs 252.458 grains, consequently 100 cubic inches will be $(252.458 \times 100) = 25245.8$ grains, or 57.7 ounces avoir. But an easier way still is to measure the water,—an ounce avoir. is equal to 1.733 cubic inches, therefore divide 100 by 1.733, and we obtain the number of ounces avoir. which corresponds to 100 cubic inches. It is always best, however, to use a gauge made by a regular maker, if possible, as inaccurate records are worse than none.

Usually a one-inch measure is so large a glass, that half an inch is considered more convenient.

the mean, and some vapor therefore necessarily falls as fog or rain. Thus one saturated current being at 40°, and the other at 60°, the resultant temperature will be 50°, but the amount of invisible vapor will not be the mean, viz., 4.315, but 4.1; an amount equal to .215 will therefore be deposited.

Rain is therefore owing to the cooling of a saturated air, and rain is heaviest under the following conditions,—when, the temperature being high, and the amount of vapor large, the hot and moist air soon encounters a cold air. These conditions are chiefly met with in the tropics, when the hot air, saturated with vapor, impinges on a chain of lofty hills over which the air is cold. The fall may be 130 to 160 inches, as on the Malabar coast of India, or 180 to 220 in Southern Burmah, or 600 at Cherrapoonjee, in the Khasyah Hills. Even in our own country the hot air from the Gulf Stream impinging on the Cumberland Hills causes, in some districts, a fall of 80, 100, 200, and even more inches in the year.

The rainfall in different places is remarkably irregular from year to year; thus at Bombay the mean being 76, in 1822 no less than 112 inches, while in 1824 only 34 inches fell.

The amount of rain at the different foreign stations is given under the respective headings.

SECTION V.

EVAPORATION.

The amount of evaporation from a given moist surface is a problem of great interest, but it is not easy to determine it experimentally, and no instrument is issued by the Army Medical Department. A shallow vessel of known area, protected around the rim by wire to prevent birds from drinking, is filled with a known quantity of water, and then, weekly or monthly, the diminution of the water is determined, the amount added by rain as shown by the rain-gauge being of course allowed for.

Water has been placed under a cover, which may protect it from rain and dew, and yet permit evaporation, and the loss weighed daily; but it is impossible to insure that the evaporation shall be equal to that under the free heavens.

A third plan is calculating the rate of evaporation from the depression of the wet bulb thermometer, by deducting the elastic force of vapor at the dew-point temperature from the elastic force at the air temperature, and taking the difference as expressing the evaporation. This difference expresses the force of escape of vapor from the moist surface.

Instruments termed *Atmometers* have been used for this purpose; the first was invented by Leslie. A ball of porous earthenware was fixed to a glass tube, with divisions, each corresponding to an amount of water which would cover the surface of the ball with a film equal to the thickness of $\frac{1}{1000}$th part of an inch. The evaporation from the surface of the ball was then read off. Dr. Babington has also invented an ingenious *Atmidometer*.[1]

The amount of evaporation is influenced by temperature, wind, humidity of the air, rarefaction of the air, degree of exposure or shading, and by the nature of the moist surface; it is greater from moist soil than from water.

[1] See Negretti & Zambra's Treatise, p. 141, for details.

The amount of vapor annually rising from each square inch of water surface in this country has been estimated at from 20 to 24 inches; in the tropical seas it has been estimated at from 80 to 130, or even more inches. In the Indian Ocean it has been estimated at as much as an inch in twenty-four hours, or 365 in the year, an almost incredible amount. No doubt, however, the quantity is very great.

It requires an effort of imagination to realize the immense distillation which goes on from the tropical seas. Take merely 60 inches as the annual distillation, and reckon this in feet instead of inches, and then proceed to calculate the weight of the water rising annually from such a small space as the Bay of Bengal. The amount is almost incredible.

This distillation of water serves many great purposes; mixing with the air it is a vast motive power, for its specific gravity is very low (.6230, air being 1), and it causes an enlargement of the volume of air; the moist air is therefore much lighter, and ascends with great rapidity; the distillation also causes an immense transference of heat from the tropics, where the evaporation renders latent a great amount of heat, to the extra-tropical region where this vapor falls as rain, and consequently parts with its latent heat. The evaporation also has been supposed to be a great cause of the ocean currents (Maury), which play so important a part in the distribution of winds, moisture, and warmth.

SECTION VI.

WIND.

Direction.—For determining the direction of the wind a vane is necessary. It should be placed in such a position as to be able to feel the influence of the wind on all sides, and not be subjected to eddies by the vicinity of buildings, trees, or hills. The points must be fixed by the compass;[1] the magnetic declination being taken into account; the declination of the place must be obtained from the nearest observatory; in this country it is now about 21° (or two points) to the westward of true north.[2] The direction of the wind is registered twice daily in the army returns, but any unsual shifting should receive a special note. The course of the wind is not always parallel with the earth; it sometimes blows slightly downward; contrivances have been employed to measure this, but the matter does not seem important.

Various plans are resorted to for giving a complete summary of the winds, but this is not required from the medical officer.

Velocity.—A small Robinson's anemometer is now supplied to each station; it is read every twenty-four hours, and marks the horizontal movement in the preceding twenty-four hours.

This anemometer consists of four small cups,[3] fixed on horizontal axes of such a length (1.12 foot between two cups), that the centre of a cup, in one revolution, passes over $\frac{1}{1500}$th of a mile, the circumference being 3.52 feet. These cups revolve with about a third of the wind's velocity; 500 revolutions of the cups are therefore supposed to indicate one mile, and

[1] Or, better still, by the pole star.

[2] Thus N. magnetic will be N.N.W. true, S. magnetic S.S.E. true, and so on.

[3] The current of air is opposed one-fourth more by a concave surface than by a convex one the same size.

by an arrangement of wheels, the number of miles traversed by the wind can be approximately ascertained.

Osler's anemometer is a large and very beautiful instrument. It registers simultaneously on a piece of paper fitted on a drum, which is turned by clock-work, direction, velocity, and pressure.

Other anemometers, Lind's, Whewell's, etc., need not be described.

The average velocity of wind in this country near the surface of the earth is from six to eight miles per hour; its range is from zero to 60 or even 70 miles per hour, but this last is very rare; it is seldom more, even in heavy winds, than 35 to 45 miles per hour. In the hurricanes of the Indian and China seas it is said to reach 100 to 110 miles per hour.

Force.—The force of the wind is reckoned as equal to so many pounds or parts of a pound on a square foot of surface. Osler's anemometer, as just stated, registers the force as well as the velocity and direction, but Robinson's (used in the army) marks only the velocity; the force must then be calculated. The rule for the calculation of the force from the velocity is as follows:—

Ascertain the mean velocity per hour by observing the velocity for a minute, and multiplying by 60; then square the hourly velocity and multiply by .005. The result is the pressure in pounds or parts of a pound per square foot.

The formula is, if V = velocity per hour,

$$V^2 \times .005 = P.$$

If the force be given, the velocity may be found:

$$\sqrt{200\,P} = V.$$

When no anemometer is in use, the Beaufort scale may be employed, 0 = calm, about 3 miles an hour, and 12 = hurricane, 90 miles and over.

SECTION VII.

CLOUDS (PLATE IX.).

The nomenclature proposed by Howard[1] is now almost universally adopted.

There are three principal forms and four modifications.

Principal Forms.

Cirrus.—Thin filaments, which by association form a brush, or woolly hair, or a slender network. They are very high in the atmosphere, probably more than ten miles, but the exact height is unknown. It has even been questioned whether they are composed of water; if so, it must be frozen. In this climate they come from the northwest.

Cumulus.—Hemispherical or conical heaps like mountains rising from a horizontal base; cumuli are often compared to balls of cotton.

Stratus.—A widely extended, continuous horizontal sheet, often forming at sunset.

Modifications.

Cirro-cumulus.—Small rounded, well-defined masses, in close, horizontal arrangement; when the sky is covered with such clouds it is said to be fleecy.

[1] Climate of London.

Cirro-stratus.—Horizontal strata or masses, more compact than the cirri; at the zenith they seem composed of a number of thin clouds; at the horizon they look like a long narrow band.

Cumulo-stratus.—Stratus blended with the cumulus.

Cumulo-cirro-stratus, Nimbus, or Rain-cloud.—A horizontal sheet above which the cirrus spreads, while the cumulus enters it laterally or from below.

Of the above forms Nos. 1, 2, and 3 of the plate (copied by permission from Mr. Scott's "Instructions") are "upper" clouds; the others are "lower" clouds. To those described is added the form shown in No. 5, viz., *Roll-cumulus*, which consists of portions of cumulus rolled into a cylindrical shape, and either separate or packed together, as shown in the plate. Alongside the names in the plates are contractions, which ought to be used in description.

Estimation of Amount of Cloud.—This is done by a system of numbers: 0 expresses a cloudless sky, 10 a perfectly clouded sky, the intermediate numbers various degrees of cloudiness. To get these numbers, look midway between the horizon and zenith, and then turn slowly round, and judge as well as can be done of the relative amount of clear and clouded sky. This is to be entered without reference to the thickness of the cloud.

SECTION VIII.

OZONE.[1]

Papers covered with a composition of iodide of potassium and starch, and exposed to the air, are supposed to indicate the amount of ozone present in the atmosphere. Schönbein, the discoverer of ozone, originally prepared such papers, and gave a scale by which the depth of blue tint was estimated. Subsequently similar but more sensitive papers were prepared by Dr. Moffat, and Mr. Lowe afterward improved on Moffat's papers, and also prepared some ozone powders.

The papers are exposed for a definite time to the air, if possible with the exclusion of light, and the alteration of color is compared with a scale.

Schönbein's proportions are—1 part of *pure* iodide of potassium, 10 parts starch, and 200 parts of water. Lowe's proportion is 1 part of iodide to 5 of starch; Moffat's proportion is 1 to 2¼. The starch should be dissolved in cold water, and filtered so that a clear solution is obtained; the iodide is dissolved in another portion of water, and is gradually added. Both must be perfectly pure; the best arrowroot should be used for starch.

The paper, prepared by being cut into slips (so as to dry quicker and to avoid loss of the powder in cutting) and soaked in distilled water, is placed in the mixed iodide and starch for four or five hours, then removed with a pair of pincers, and slowly dried in a cool dark place, in a horizontal position. The last point is important, as otherwise a large amount of the iodide drains down to one end of the paper, and it is not equally diffused. The papers when used should hang loose in a place protected from the sun and rain; a box is unnecessary; they should not be touched with the fingers more than can be helped when they are adjusted.

[1] For a full account of the tests of ozone, see Dr. Fox's work on Ozone and Antozone, 1873, already referred to. After discussing all the tests, he gives the preference to the iodine plan. He has not found Schönbein's thallium method satisfactory.

When Schönbein's papers are used they are moistened with water after exposure, but before the tint is taken. Moffat's papers are prepared somewhat similarly to Schönbein's, but do not require moistening with water.

The estimation of ozone is still in a very unsatisfactory state, and this arises from two circumstances.

1. The fact that other substances besides ozone act on the iodide of potassium, especially nitrous acid, which is formed in some quantity during electrical storms. Cloez has shown that air taken about one metre above the ground often contains nitrous acid in sufficient quantity to redden litmus. Starch and iodide paper is colored when air contains .00005 of its volume of nitrous acid.

2. The fact that the papers can scarcely be put under the same conditions from day to day; light, wind, humidity, and temperature (by expelling the free iodine) all affect the reaction.

Chemical objections have also been made.[1] Supposing that iodine is set free by ozone, a portion of it is at once changed by additional ozone into iodozone, which is extremely volatile at ordinary temperatures, and is also changed by contact with water into free iodine and iodic acid. Hence a portion of the iodine originally set free never acts on the starch, being either volatilized or oxidized. Again, the iodine and caustic potash set free by the ozone combine in part again, and form iodate and iodide of potassium ($\frac{1}{6}$th of the former and $\frac{5}{6}$ths of the latter), and in this way the blue color of iodide of starch first produced may be removed. The ozone may possibly, and probably, act on and oxidize the starch itself, and hence another error.

The conclusion arrived at by the Vienna congress was the following: "The existing methods of determining the amount of ozone in the atmosphere are insufficient, and the congress therefore recommends investigations for the discovery of better methods."

SECTION IX.

ELECTRICITY.

The instruments used by meteorologists are simple electroscopes, with two gold-leaf pieces which diverge when excited, or dry galvanic piles acting on gold-leaf plates or an index attached to a Leyden jar (Thomson's electrometer). For further details, see Scott's "Instructions," op. cit.

SECTION X.

THERMOMETER STAND.

A stand is issued by the War Office, and provided at every station. Or it would be very easy to make a stand by two or three strata of boards, placed about 6 inches apart, so as to form a kind of sloping roof over the thermometers, which are suspended on a vertical board.

The dry and wet bulb thermometers are placed in the centre; the maximum on the right side, and the minimum on the left. The wood

[1] Beiträge zur Ozonometrie, von Dr. v. Maach; Archiv für Wiss. Heilk., Band ii., p. 29.

should be cut away behind the bulbs of the maximum and minimum thermometers, so as to expose them freely to the air. The bulbs of the dry and wet bulbs should also fall below the board. These stands are made to rotate on the pole so as to turn the roof always to the sun.

A much better stand is Stevenson's screen, a square or oblong box, with double louvred sides and open below. This is raised upon legs, four feet from the ground, placed upon grass.[1]

SECTION XI.

WEATHER.

In registering the kind of weather it is well to adhere to the Beaufort notation and symbols, which are carefully explained in Scott's "Instructions." Columns are given in the return to be filled up in this way.

SECTION XII.

DISEASES AND VARIATIONS IN THE METEOROLOGICAL ELEMENTS.

The variation in the prevalence of different diseases at a particular place, in connection with the simultaneous variation of meteorological elements, is an old inquiry which has at present led to few results. The reason of this is that the meteorological elements are only a few out of a great many causes affecting the prevalence and severity of diseases. Consequently, in order to estimate the real value of changes of temperature, pressure, humidity, ozone, etc., the other causes of disease, or of variations in prevalence or intensity, must be recognized and eliminated from the inquiry. The best of the late observations are those by Guy, Ransome, Vernon, Moffat, Tripe, Scoresby-Jackson, and Ballard. Observations have also been made by Fodor and others on the continent of Europe, and by various observers in America and elsewhere. But they must be much more extended and numerous before anything practical can be drawn from them.

[1] Scott's Instructions, Fig. 10, p. 41.

CHAPTER XVI.

INDIVIDUAL HYGIENIC MANAGEMENT.

This subject is an extremely large one, and the object of this book does not permit of its discussion. It would require a volume to itself. Only a few very general remarks can be made here. The application of general hygienic rules to a particular case constitutes individual management.

It is impossible to make general rules sufficiently elastic, and yet precise enough, to meet every possible case. It is sufficient if they contain principles and precepts which can be applied. While individual hygiene should be a matter of study to all of us, it is by no means desirable to pay a constant or minute attention to one's own health. Such care will defeat its object. We should only exercise that reasonable care, thought, and prudence which, in a matter of such moment, every one is bound to take.

Every man, for example, who considers the subject *bonâ fide*, is the best judge of the exact diet which suits him. If he understands the general principles of diet, and remembers the Hippocratic rule, that the amount of food and exercise must be balanced, and that evil results from excess of either, he is hardly likely to go wrong.

"Temperance and exercise," was the old rule laid down, even before Hippocrates,[1] as containing the essence of health; and if we translate temperance by "sufficient food for wants, but not for luxuries," we shall express the present doctrine.

The nutrition of the body is so affected by individual peculiarities, that there is a considerable variety in the kind of food taken by different persons. The old rule seems a good one, viz., while conforming to the general principles of diet, not to encourage too great an attention either to quantity or to quality, but avoiding what experience has shown to be manifestly bad, either generally or for the particular individual, to allow a considerable variety and change in amount from day to day, according to appetite.[2] Proper and slow mastication of the food is necessary; and it is

[1] It is quite plain from the context, that Hippocrates, by temperance, meant such an amount of food as would balance, and neither exceed nor fall short of the exercise. He had a clear conception of the development of mechanical force from, and its relation to, food. He lays down rules to show when the diet is in excess of exercise, or the exercise in excess of diet. In either case he traces disease.

[2] Celsus carried the plan of variety so far as to recommend that men should sometimes eat and drink more than is proper, and should sometimes not exceed; and Lord Bacon has a remark which leads one to believe he held a similar opinion; but there can be no doubt of the incorrectness of this opinion. It has been truly said that the first general rule of Hippocrates, which prescribes continual moderation, is much truer, and the best writers on hygiene, ancient and modern, have decided against Celsus. Besides being erroneous, the rule of Celsus opens a door to intemperance, and, like a harmless sentence in Hippocrates, has been twisted to serve the argument of gourmands. Its influence is felt even at the present day. This much is certain, that prob-

extraordinary how many affections of the stomach called dyspepsia arise simply from faulty mastication, from deficient teeth, or from swallowing the food too rapidly. Many persons who are too thin are so from their own habits; they eat chiefly meat, and eat it very fast; they should eat slowly, and take more bread and starchy substances. Fat persons, on the other hand, by lessening the amount of starch, and taking more exercise, can lessen with the greatest ease the amount of fat to any amount. It must be remembered, however, that there is a certain individual conformation in this respect; some persons are normally fatter or thinner than others.

The exact amount of exercise must also be a matter of individual decision, it being remembered that exercise in the free air is a paramount condition of health, and that the healthiest persons are those who have most of it. As a rule, persons take far too little exercise, especially educated women, who are not obliged to work, and the muscles are too often flaccid and ill-nourished.[1]

Attention to the skin is another matter of personal hygiene. The skin must be kept perfectly clean and well clothed. Some writers, indeed, have advised that, if food be plentiful, few clothes be worn; but the best authors do not agree in this, but recommend the surface to be well protected. For cleanliness, cold bathing and friction hold the first rank. The effect of cold is to improve apparently the nutrition of the skin, so that it afterward acts more readily, and when combined with friction, it is curious to see how the very color and texture of the skin manifestly improve.

The effect of heat on the skin, and especially the action of the Roman or Turkish baths, and their action on health, have certainly not yet been properly worked out, in spite of the numerous papers which have been written. It has not been proved that the strong action of the Turkish bath is more healthy in the long run than the application of cold water. As a curative agent, it is no doubt extremely useful; but as a daily custom, it is yet *sub judice*. Certainly it should not be used without the concluding application of cold to the surface.

Attention has been often very properly directed to the effect of lead and mercurial hair-dyes. It may be worth while to notice that there is a case on record[2] in which not only was paralysis produced by a lead hair-wash, but lead was recovered from the base of the left hemisphere of the brain. Snuff containing lead has also caused poisoning.

The care of the bowels is another matter of personal hygiene, and is a matter of much greater difficulty than at first sight appears. Constipation, as allowing food to remain even to decomposition, as leading to distention and sacculation of the colon, and to hemorrhoids, is to be avoided. But, on the other hand, the constant use of purgative medicine is destructive of digestion and proper absorption; and the use of clysters, though less

ably 30 per cent. of the persons who consult physicians owe their diseases in some way to food, and in many cases they are perfectly aware themselves of their error or bad habit, but, with the singular inconsistency of human nature, either conceal it from the man to whom they are professing perfect openness, or manage to blind themselves to its existence.

[1] Compare the imperfect development of the muscles of the arms in ladies, as shown by the low evening dresses, with the women of the working classes. No one can doubt which is healthiest or which is the most beautiful, until excess of work develops in the muscles of the laboring women the too hard outlines of middle life.

[2] Virchow's Archiv, Band viii., p. 177.

hurtful to the stomach, and less objectionable altogether, is by no means desirable. On the whole, it would seem that proper relief of the bowels can be usually insured by exercise, and especially by bringing the abdominal muscles into play, and by the use of certain articles of diet—viz., pure water in good quantity with meals, the use of bran bread, honey, and such gently laxative food; and that if these do not answer well, it is better to allow a certain amount of constipation than to fall into the frequent use of purgative medicines.

The regulation of the passions must also be left to the individual. The control of morals has baffled the exertions of the priest and the statesman; but perhaps the influence of sexual irregularities on health has never been made the subject of judicious education. The period of puberty corresponds with the most important period of growth, when the bones are consolidating and uniting, and both muscles and nerves are largely absorbing nourishment, and are developing to their fullest power. The too early use of sexual congress, and even more the drain on the system produced by solitary vice, arrests this development to a considerable extent, and prevents the attainment of the strength and endurance which would insure a healthy, vigorous, and happy life. The venereal diseases, which so waste many of the younger men, form only an item in the catalogue of evils—evils which effect at a subsequent period wives and children, and by undermining the health and happiness of the family, influence the state itself. We know that a wide-spread profligacy has eaten away the vigor of nations and caused the downfall of states; but we hardly recognize that, in a less degree, the same causes are active among us, and never realize what a state might be if its citizens were temperate in all things. It may be difficult to teach these points to the young, and to urge upon them, for their own and others' sakes, the regulation of the passions which physiology teaches to be necessary for personal happiness, for the welfare of the offspring, and for healthy family life; but I think few can doubt that, in some way, the knowledge should be given.

The amount of mental work, and the practice of general good temper and cheerfulness and hope, are other points which each man must himself control. Great mental work can be borne well if hygienic principles of diet, exercise, etc., be attended to. The old authors paid great attention to the regimen of men engrossed in literary work, and laid down particular rules, insisting especially on a very careful and moderate diet, and on exercise.[1]

Hope and cheerfulness are great aids to health, no doubt, from their effect on digestion. Usually, too, they are combined with a quick and active temperament, and with rapid bodily movements and love of exercise.

The individual application of general hygienic rules will differ according to the sex and age,[2] and the circumstances of the person. In the case of children, we have to apply the general rules with as much caution and care as possible, as we must depend on external evidence to prove their

[1] Plutarch, whose rules on health are excellent and chiefly taken from Hippocrates, compares the over-studious man to the camel in the fable, who, refusing to ease the ox in due time of his load, was forced at last to carry not only the ox's own load, but the ox himself, when he died under his burden.

[2] Galen was the first who pointed out explicitly that hygiene rules must be diffesent for infancy, youth, manhood, and old age—a fourfold division which is still the best. Pythagoras, Iccus, Herodicus, Hippocrates, Polybius, Diocles, Celsus, and others who preceded Galen, appear to have framed rules chiefly for male adults. Galen subdivided the subject much more systematically. (For a good short account of the early systems, see Mackenzie on The History of Health, and the Art of Preserving it, 1758.)

utility. In the case of adults, individual experience soon shows whether or not a prescribed rule is or is not beneficial, and what modification must be made in it. It is not, however, every grown person who has the power to modify or change his condition. He may be under the influence of others who, in fact, arrange for him the circumstances of his life. But still, in no case is all self-control taken away; the individual can always influence the conditions of his own health.

Were the laws of health and physiology better understood, how great would be the effect! Let us hope that matters of such great moment may not always be considered of less importance than the languages of extinct nations, or the unimportant facts of a dead history.

CHAPTER XVII.

DISPOSAL OF THE DEAD.

In densely populated countries the disposal of the dead is always a question of difficulty. If the dead are buried, so great at last is the accumulation of bodies that the whole country round a great city becomes gradually a vast cemetery.[1] In some soils the decomposition of bodies is very slow, and it is many years before the risk of impurities passing into air and water is removed.

After death the buried body returns to its elements, and gradually, and often by the means of other forms of life which prey on it, a large amount of it forms carbon dioxide, ammonia, carburetted hydrogen and hydrogen sulphide, nitrous and nitric acids, and various more complex gaseous products, many of which are very fetid, but which, however, are eventually all oxidized into the simpler combinations. The non-volatile substances, the salts, become constituents of the soil, pass into plants, or are carried away into the water percolating through the ground. The hardest parts, the bones, remain in some soils for many centuries, and even for long periods retain a portion of their animal constituents.

If, instead of being buried, the body is burned, the same process occurs more rapidly and with different combinations; carbon dioxide, carbon monoxide (?), nitrogen, or perhaps combinations of nitrogen, water, etc., are given off, and the mineral constituents, and a little carbon, remain behind.

A community must always dispose of its dead either by burial in land or water, or by burning, or chemical destruction equivalent to burning, or by embalming and preserving. Accustomed as we are to land burial, there is something almost revolting, at first sight, at the idea of making the sea the sepulchre, or of burning the dead. Yet the eventual dispersion of our frames is the same in all cases; and it is probably a matter merely of custom which makes us think that there is a want of affection, or of care, if the bodies of the dead are not suffered to repose in the earth that bore them.

In reality, neither affection nor religion can be outraged by any manner of disposal of the dead which is done with proper solemnity and respect to

[1] Nothing, perhaps, testifies more strongly to the antiquity and the extent of the ancient cities in Anatolia than the vast sepulchral remains. On the site of Old Dardanus, the mother of Troy, and stretching from the Hellespont for two or three miles into the hills, the whole country is honeycombed with tombs. It is the same in the neighborhood of Troy. The burial of the dead, though practised by the most ancient nations, was afterward superseded by burning, and was only subsequently returned to. As, therefore, these graves represent only a portion of the duration of the city, the immense assemblage of tombs is the more remarkable, and it is impossible to avoid the conclusion that these great cities must have flourished for periods far longer than those which have elapsed since London or Paris, for example, became large centres of population.

the earthly dwelling-place of our friends. The question should be placed entirely on sanitary grounds, and we then shall judge it rightly.

What, then, is the best plan of disposing of the dead, so that the living may not suffer?

It seems hardly likely that the practice of embalming or mummifying will ever again become common. What is the use of preserving for a few more years the remains which will be an object of indifference to future generations? The next logical step would be to enshrine these remains in some way so as to insure their preservation, and we should return to the vast burial mounds of Egypt. The question will lie between burial in the land or at sea, and burning.

At present the question is not an urgent one; but if the population of Europe continues to increase, it will become so in another century or two. Already in this country we have seen, in our own time, a great change; the objectionable practice of interment under and round churches in towns has been given up, and the population is buried at a distance from their habitations. For the present that measure will probably suffice, but in a few years the question will again inevitably present itself.

Burying in the ground appears certainly the most insanitary plan of the three methods. The air over cemeteries is constantly contaminated, and water (which may be used for drinking) is often highly impure. Hence, in the vicinity of graveyards two dangers to the population arise, and in addition, from time to time, the disturbance of an old graveyard has given rise to disease. It is a matter of notoriety that the vicinity of graveyards is unhealthy. How are these dangers to be avoided? The dead may be buried in more or less air-tight vaults; here decay is slow; the products form and escape slowly, though they must eventually escape; the air and water are less contaminated. But the immense expense of such a plan renders it impossible to adopt it for the community generally. Deep burying has the advantage of greater filtration, both for air and water, than shallow burying, and hence it is a good rule to make the grave as deep as possible, and to allow no more than one body in a grave. The admixture of quicklime has been advised; it absorbs some carbon dioxide, and forms calcium sulphide with the sulphur and hydrogen sulphide, but this itself soon decomposes, so that the expense of quicklime seems hardly commensurate with the result. Charcoal would absorb and oxidize the fetid organic matter, and, if sufficiently cheap, would be a valuable substance to be heaped in graves; but its cost would be probably too great, nor does it entirely hinder putrefaction and the evolution of foul-smelling substances (H. Barker). If a body has to be kept unburied for some time, sawdust and sulphate of zinc, in the proportion of two parts to one, has been found by Herbert Barker,[1] to be the best application; a thin layer is put over the dead body; or sawdust is sprinkled on the body, and then two or three inches of carbolic acid thrown over it.

The only means which present themselves, as applicable in all cases, are the deep burial and the use of plants, closely placed in the cemetery. There is no plan which is more efficacious for the absorption of the organic substances, and perhaps of the carbon dioxide, than plants, but it would seem a mistake to use only the dark, slow-growing evergreens. The object should be to get the most rapidly growing trees and shrubs, and, in fact, there is no reason, except a feeling of sentiment, why we should introduce into our cemeteries the gloomy and melancholy cypress and yew. Mr.

[1] Deodorization and Disinfection, British Medical Journal, January, 1866.

Seymour Haden has called attention to the supposed advantages of perishable coffins, so that the putrefactive changes may be carried out as quickly as possible. And certainly, if burying is to continue, it seems reasonable that no undue obstacle should be placed in the way of changes which are sooner or later inevitable.

When, in the course of years, it becomes imperative to reconsider this question, and land burial will have to be modified, some arguments may present themselves to maritime nations in favor of burying in the sea rather than of burning. In the burial at sea, some of the body at least would go at once to support other forms of life, more rapidly than in the case of land burial, and without the danger of evolution of hurtful products.

Burning, or cremation, has attracted much attention of late years. In this country the subject has been discussed by Sir Henry Thompson and Mr. Eassie, and abroad much has been written, especially in Germany and Italy, in both which countries the method has been practically tried. It would certainly appear that the body can be disposed of in a very short time and in an inoffensive manner, while the expense would unquestionably be much reduced if the practice became general. One hour appears sufficient to reduce a body to ashes, and it has been successfully tried in this country.

The only really valid argument against cremation is the possible concealment of crime, such as poisoning. This, however, might be guarded against by suitable precautions.

In time of war, and especially in the case of beleaguered fortresses, the disposal of the dead becomes often a matter of difficulty. In that case burning may have to be resorted to. If the bodies are buried, they should always be at as great a distance as possible, and as deep as they can be. If procurable, charcoal should be thrown over them; if it cannot be obtained, sawdust and sulphate of zinc, or carbolic acid may be employed. Quicklime is also commonly employed, but it is less useful.

At Metz, in 1870, the following plan was adopted:—A pit of about 17 feet in depth was filled with dead, disposed of as follows:—A row of bodies was laid side by side; above this a second row was placed, with the heads laid against the feet of the first row; the third row were placed across, and the fourth row in the same way, but with the heads to the feet of the former; the fifth row were placed as No. 1, and so on. Between each layer of bodies about an inch of lime, in powder, was placed. From 90 to 100 bodies were thus arranged on a length of 6½ feet, and reached to about 6 feet from the surface; the pit was then filled up with earth, and though 8,400 bodies were put in that pit, there were no perceptible emanations at any time.

Around Metz the graves of men and horses and cattle were disinfected with lime, charcoal, and sulphate of iron. Immense exertions were made to clean and disinfect the camps and battle-fields, and in the month of May, 1871, from 1,200 to 1,600 laborers were employed by the Germans. Wherever practicable, the ground was sown with oats or barley or grass. The hillocks formed by the graves were planted with trees.

In many cases, at Metz, bodies were dug up by the Germans when there was any fear of watercourses being contaminated, or if houses were near. On account of the danger to the workmen, graves containing more than six bodies were left untouched, and the work was always done under the immediate superintendence of a physician. The earth was removed carefully, but not far enough to uncover the corpse; then one end of the corpse was uncovered, and as soon as uniform or parts of the body were

seen, chloride of lime and sawdust, or charcoal and carbolic acid, put in; the whole earth round the body was thus treated, and the body at length laid bare, lifted and carried away. The second body was then treated in the same way.

Near Sedan, where there were many bodies very superficially buried, burning was had recourse to. Straw mixed with pitch was put into the graves, and was lighted; 1 ton of pitch sufficed for from 15 to 20 bodies. Opinions as to this practice were divided, and it is not certain how many graves were thus dealt with. It seems probable that only the surface of the body was burnt, and when many bodies were together in one grave some were not touched at all. On the whole, the experiment appears to have been unsuccessful.

The Belgian experience at Sedan was in favor of employing chloride of lime, nitric acid, sulphate of iron, and chlorine gas. Carbolic acid did not answer so well. The sulphate of zinc and charcoal, which Barker found so useful, was not tried.

Mr. Eassie has lately called attention to the desirability of an ambulatory cremation furnace for the disposal of bodies in war. If such an arrangement proved practicable, it would unquestionably be of immense advantage from a hygienic point of view.

CHAPTER XVIII.

ON THE PREVENTION OF SOME IMPORTANT AND COMMON DISEASES.

THERE are two modês by which we may attempt to prevent the occurrence of disease.

1. By conforming with the general rules of hygiene, by which the body and mind are brought into a state of more vigorous health.

2. By investigating and removing the causes of the diseases which we find actually in operation. This part of the inquiry is in fact a necessary supplement to the other, though in proportion to the observance of the general rules of hygiene, the causes of disease will gradually be removed. At present, however, we have to deal with the facts before us,—viz., that there are a great number of diseases actually existent which must form the subject of investigation. We proceed in this case from the particular to the general, whereas, in the first mode, we deduce general rules which have to be applied to individual instances.

Hygiene is in this direction an application of etiology, and etiology is the philosophy of medicine ; while in its turn the very foundation and basis of etiology is an accurate diagnosis of disease. Unless diseases are completely identified, all inquiry into causes is hopeless. Let us remember, for example, what utter confusion prevailed in our opinions as to causes and preventive measures at the time when typhus and typhoid fevers were considered identical, or when paroxysmal fever and the true yellow fever or vomito were thought to own a common cause. Any useful rules of prevention were simply impossible—as impossible as at present in many of the diseases of nutrition, which, in the proper sense of the word, are yet undiagnosed.

The advance of diagnosis has of late years been owing not merely to improved methods of observation, but to the more complete recognition of the great principle of the invariableness of causation. The sequence of phenomena in the diseased body proceeds with the same regularity and constancy as in astronomy or chemistry. Like causes always produce like effects. To suppose that from the same cause should proceed a sequence of phenomena so utterly distinct as those of typhus and typhoid fever, now seems incredible ; yet with a full, or at any rate a sufficient knowledge of the phenomena, it was at one time almost universally believed that these two perfectly distinct diseases owned a common origin. At the present moment, the superficial resemblance between gout and rheumatism causes them to be put together in almost all systems of nosology, although, with the exception of the joints being affected, the diseases have almost nothing in common.

In proportion as this great principle is still more constantly applied,

and as our means of diagnosis advance, and consequently, causes are more satisfactorily investigated, methods of prevention will become obvious and precise. At present they are very far from being so. In many cases they are founded on very imperfect observation ; and very frequently all that can be done is to apply general sanitary rules, without attempting to determine what are the special preventive measures which each disease requires.

It is not necessary, however, that we should wait until the causation of any disease is perfectly understood. We must act, as in so many other affairs, on probability ; and endeavor to remove those conditions which, in the present state of our knowledge, seem to be the most likely causes of the disease. It may be that, in some cases, we may be attacking only subsidiary or minor causes, and may overlook others equally, or more important. In some cases, indeed, we may overlook entirely the effective causes, and may be fighting with shadows. Still, even from mistakes, progress often arises —indeed, the difficult path of human knowledge is perhaps always through error.

The term cause is applied by logicians to any antecedent which has a share in producing a certain sequence ; and it is well known that in many diseases two sets of causes are in operation—one external and one internal to the body (exciting and predisposing). The investigation of the internal causes, which in some cases are necessary to the action of the external causes, is equally curious and intricate as that of the external causes, and in some respects it is even more obscure ; but measures of prevention must deal with them, as well as with the external causes.

In this chapter we can, of course, only venture to enumerate very briefly, and without discussion, what seem to be the best rules of prevention for the principal diseases of soldiers. To enter on the great subject of the prevention of disease generally, and to discuss all the complicated questions connected with causation, would demand a volume.

SECTION I.

THE SPECIFIC DISEASES.

Paroxysmal Fevers.

Exiernal Cause.—This was presumed to be putrescent, or, at any rate, decomposing vegetable matter derived from a moist and putrescent soil, which was carried into the body by the medium of water or of air. But the later views of Klebs and Tommasi-Crudeli attribute it to a low organism of the nature of *Bacillus*, to which they have given the name *Bacillus malariæ*, propagated in the presence of decaying vegetable matter.

If the ingestion is by water, a fresh source must be obtained. Well-water is generally safe, but not always. Rain-water may be unsafe, if the tanks are not clean.[1] If a fresh source cannot be obtained, boiling, filtration, and alum appear to be the best preventive measures.[2]

If the introduction be by air, and if the locality cannot be left, the most approved plan is elevation to at least 500 feet above *the source of the poison*

[1] For an instance of propagation by so-called rain-water, see cases at Tilbury Fort, Volume I., page 49.

[2] Dr. Blanc and Mr. Prideaux preserved themselves from intermittent fever, in a march in Abyssinia, by always using water in the form of tea or coffee.

in temperate climates ; and 1,000 to 1,500 feet in the tropics, or higher still, if possible.[1] If this plan cannot be adopted, two points must be aimed at —viz., to obviate local, and to avoid drifting malaria. Thorough subsoil draining ; filling up moist ground when practicable ; paving or covering the ground with herbage kept closely cut, are the best plans for the first point. For the second, belts of trees, even walls can be interposed ; or houses can be so built as not to present openings toward the side of the malarious currents.

The houses themselves should be raised above the ground on arches ; or, if wooden, on piles. Upper floors only should be occupied. The early morning air, for three hours after sunrise, should be avoided ; and next to this, night air.

Internal Causes.—The conformation, or structural condition, which permits the external cause to act, is evidently not equal in different individuals, or in different races ; but we are quite ignorant of its nature. It is not removed by attacks of the disease ; but, on the contrary, after repeated attacks of ague, a peculiar condition is produced, in which the disease can be brought on by causes, such as cold or dietetic errors, which could never have caused it in the first instance. The internal predisposition is greatly heightened by poor feeding, anæmia, and probably by scurvy.

To remove the internal causes our only means at present are the administration of antiperiodics, especially quinine ; and good and generous living, with iron medicines. The use of flannel next the skin, and of warm clothing generally ; warm coffee, and a good meal before the time of exposure to the malaria, and perhaps moderate smoking (?), are the other chief measures. Wine in moderation is part of a generous diet ; but spirits are useless, and probably hurtful, unless given considerably diluted.

Yellow Fever.

External Cause.—During the last few years the progress of inquiry has entirely disconnected true yellow fever from malaria, though yellowness of the skin is a symptom of some malarious fevers. Yellow fever is a disease of cities and of parts of cities, being often singularly localized, like cholera. In the West Indies it has repeatedly attacked a barrack (at Bermuda, Trinidad, Barbadoes, Jamaica), while no other place in the whole island was affected. In the same way (at Lisbon, Cadiz, and many other places) it has attacked only one section of a town, and, occasionally, like cholera, only one side of a street. In the West Indies, it has repeatedly commenced in the same part of a barrack. In all these points, and in its frequent occurrence in non-malarious places, in the exemption of highly malarious places, in its want of relation to moisture in the atmosphere, and its as evident connection with putrefying fecal and other animal matters, its cause differs entirely from malaria.[2]

If these points were not sufficient, the fact that the agent or poison which causes yellow fever is portable, can be carried and introduced among

[1] It must be understood that these heights are assumed to be *above* a marsh. They will not secure from malaria from marshes, if situated at that or a much greater height. A marsh at Erzeroum is 6,000 feet above sea-level ; one at Puebla, in New Mexico, is 5,000 feet ; both cause fevers.

[2] The belief in the malarious origin of yellow fever, so long and tenaciously held by many American physicians, seems to be losing ground. (See paper by Dr. Perry, read before the American Health Association, The Daily Picayune, November 23, 1873.)

a community,[1] and is increased in the bodies of those whom it attacks, indicates that the two agencies of yellow fever and paroxysmal fevers are entirely distinct.[2]

That great point being considered settled, the inquiry into the conditions of the spread of yellow fever becomes easier. The points to seize are its frequent and regular localization and its transportation. The localization at once disconnects it from any general atmospheric wave of poison; it is no doubt greatly influenced by temperature, and is worse when the temperature is above 70° Fahr. Though it will continue to spread in a colder air than was formerly supposed, it does not spread rapidly, and appears to die out; but even temperature does not cause it to become general in a place.

The localizing causes are evidently (cases of Lisbon, Gibraltar, West Indies, etc.) connected with accumulation of excreta round dwellings, and overcrowding. Of the former there are abundant instances, and it is now coming out more and more clearly that, to use a convenient phrase, yellow fever, like cholera and typhoid fever, is a fecal disease. And here we find the explanation of its localization in the West Indian barracks in the olden time. Round every barrack there were cesspits, often open to sun and air. Every evacuation of healthy and sick men was thrown into perhaps the same places. Grant that yellow fever was somehow or other introduced, and let us assume (what is highly probable) that the vomited and fecal matters spread the disease, and it is evident why, in St. James' Barracks at Trinidad, or St. Ann's Barracks at Barbadoes, men were dying by dozens, while at a little distance there was no disease. The prevalence on board ship is as easily explained. Granted that yellow fever is once imported into the ship, then the conditions of spread are probably as favorable as in the most crowded city; planks and cots get impregnated with the discharges, which may even find their way into the hold and bilge. No one who knows how difficult it is to help such impregnation in the best hospitals on shore, and who remembers the imperfect arrangements on board ship for sickness, will doubt this. Then, in many ships, indeed in almost all in unequal degrees, ventilation is most imperfect, and the air is never cleansed.

Overcrowding, and what is equivalent, defective ventilation, is another great auxiliary; and Bone[3] relates several striking instances.[4]

[1] Cases of the Bann, Eclair, Icarus, and several others. The remarkable introduction of yellow fever from Havana into St. Nazaire, in France (near Brest), is most striking, and cannot be explained away. It spread both from the ship, and, in one instance, from persons. (See Aitken's Medicine, 7th edit., 1880; and Report on Hygiene for 1862, in the Army Medical Report, by Dr. Parkes.) The introduction into Rio in 1849, and into Monte Video, are still more striking cases of importation; and a case very similar to that of St. Nazaire occurred some years ago at Swansea. (See Report (by Dr. Buchanan) to the Medical Officer of the Privy Council, 1866.)

[2] As more care is taken, the symptoms of the two diseases also are found to be diagnostic, and if it were not for the constant use of the unhappy term "remittent," the confusion would not have so long prevailed.

An interesting instance of good diagnosis was made by the French at Vera Cruz in 1861. In the spring the vomito prevailed, and then disappeared. Some months afterward, cases of a disease occurred so like yellow fever that they were at first taken to be that disease, but on a closer examination they were found to be clearly paroxysmal, and to yield to quinine.—Rec. de Mem. de Méd. Milit., 1863.

[3] Yellow Fever, by G. F. Bone, Assistant Surgeon to the Forces.

[4] For example, in the same barrack, the windward rooms have been quite healthy, and the leeward rooms attacked. Men in the latter have ceased to have cases of the disease when moved to the former locality. (See a good case in Bone, op. cit., p. 13.)

The question of the origin of yellow fever is one which cannot be considered in this work, and at present no preventive rules of importance can be drawn from the discussion.

The chief preventive measures for the external cause are these :—

1. The portability being proved, the greatest care should be taken to prevent introduction, either by sick men, or by men who have left an infected ship. The case of the Anne Marie [1] has made it quite uncertain what period of time should have elapsed before an infected ship can be considered safe; in fact, it probably cannot be safe until the cargo has been discharged and the ship thoroughly cleansed. Still, it appears, that if men leaving an infected place or ship pass into places well ventilated and in fair sanitary condition, they seldom carry the disease; in other words, the disease is seldom portable by men, but it will occur. It appears necessary, also, to consider that the incubative period is longer than usually supposed, probably often fourteen or sixteen days. In the case of a ship, it seems desirable not to consider danger over until at least twenty days have elapsed since the cure or death of the last case, and even at that time to thoroughly fumigate the ship with chlorine and nitrous acid before the cargo is touched. Men working on board such a ship should work by relays, so as not to be more than an hour at a time in the hold.[2]

In case men sick with yellow fever must be received into a barrack or hospital, they should be isolated, placed in the best ventilated rooms at the top of the house, if possible, or, better still, in separate houses, and all discharges mixed with zinc sulphate and zinc chloride, and separately disposed of, and not allowed to pass into any closet or latrine.

2. The introduction by drinking-water not being disproved, care should be taken that the possibility of this mode of introduction be not overlooked.

3. Perfect sewerage and ventilation of any station would probably in great measure preserve from yellow fever, but in addition, in the yellow fever zone, elevation is said to have a very great effect, though the confusion between malarious fevers and the vomito renders the evidence on this point less certain, and its introduction into Newcastle in Jamaica (4,200 feet), and its frequent occurrence at Xalapa (4,330 feet), as well as its prevalence on high points of the Andes (9,000 feet) (A. Smith), show that the effect of mere elevation has been overrated. Still, as a matter of precaution, stations in all yellow fever districts should be on elevations above 2,000, and if possible 3,000 feet.

4. If an outbreak of yellow fever occur in a barrack, it is impossible then to attempt any cleansing of sewers; the only plan is to evacuate the barracks. This has been done many times in the West Indies with the best effects. As a preventive measure, also, evacuation of the barracks, and encampment at some little distance, is a most useful plan. Before the barrack is reoccupied, every possible means should be taken to cleanse it; sewers should be thoroughly flushed; walls scraped, limewashed, and fumigated with nitrous acid. If a barrack cannot be altogether abandoned, the ground floors should be disused. There are several instances in which persons living in the lowest story have been attacked, while those above have escaped.

[1] See Aitken's Medicine, and Report on Hygiene in the Army Medical Report for 1862.

[2] Dr. Perry (op. cit.) considers quarantine useless, and advises a most rigorous system of disinfection. He cites eight instances of the introduction of yellow fever through a strict quarantine, seven to New Orleans, and one to Pensacola.

5. In all buildings where sick are, or where yellow fever prevails, there should be constant fumigation with nitrous acid, which seems to be, as far as we know, the best disinfectant for this disease.

6. If it appears on board ship, take the same precautions with regard to evacuations, bedding, etc. Treat all patients in the open air on deck, if the weather permit; run the ship for a colder latitude; land all the sick as soon as possible, and cleanse and fumigate the ship.

Internal Cause.—Recent arrival in a hot country has been usually assigned as a cause, but the confusion between true yellow fever and severe febricula (ardent fever or causus) and malarious fevers, renders it uncertain how far this cause operates.[1] Still, as a matter of precaution, the present plan of three or four years' Mediterranean service before passing to the West Indies seems desirable, although this has been questioned by some experienced officers. Different races possess the peculiar habit which allows the external cause to act in very different degrees; this is marked in the cases of negroes and mulattoes as compared with white men, but even in the European nations it has been supposed that the northern are more subject than the southern nations. Of the sexes, women are said to be less liable than men.

This predisposition is increased by fatigue,[2] and it is said, especially when combined with exposure to the sun; by drinking, and by improper food of any kind which lowers the tone of the body.

No prophylactic medicine is known; quinine is quite useless.

Little, therefore, can be done to avert the internal causes, except care in not undergoing great fatigue, temperance, and proper food. The external conditions are the most important to attend to.

Dengue.

This disease, which has attracted much attention of late years, appears to bear some relation to yellow fever, not in its pathological characters, but in the time of its appearance and geographical distribution. It has, however, prevailed in Asia, where yellow fever has hitherto been unknown. In Egypt (according to Vauvray) it is seen at the time of the date-harvest, and is known as "date fever." In other parts of the world it has been attributed to vegetable emanations. Although its symptoms are those of blood-poisoning, it may be doubted if this is due to vegetable emanations only. Dr. J. Christie[3] thinks that the Dengue of the Eastern and the Dandy fever of the Western Hemisphere are varieties of the same disease, produced in the one case by the virus of yellow fever, and in the other by that of cholera, modified by local conditions of an insanitary kind, chiefly decomposition of bodies improperly interred. He suggests general hygienic measures, and especially improved methods of burial, as the best preventives.

[1] In the old times in Jamaica it was, however, always noticed that the worst attacks occurred in regiments during the first twenty-four, and especially the first twelve months. In thirteen epidemics in different regiments, four occurred in less than six months after landing, seven in less than twelve months, and two in less than twenty-four months. But it has been stated that residence in one place, though it may secure against the yellow fever of that, does not protect against the disease in another locality. It is much to be wished that all these assertions which abound in books should be tested by figures. That is the only way of coming to a decision.

[2] Arnold, Bilious Remittent Fever, 1840, p. 32.

[3] Transactions of the International Medical Congress, 1882, vol. iv., p. 636.

Cholera.

External Cause.—As in the case of yellow fever, we have no certain clue to the origin of cholera,[1] and in some respects the propagation of the disease is very enigmatical. The way, for example, in which the disease has spread over vast regions, and has then entirely disappeared,[2] and the mode in which it seems to develop and decline in a locality, in a sort of regular order and at certain seasons, are facts which we can only imperfectly explain.

But as far as preventive measures are concerned, the researches of late years seem to have given us indications on which we are bound to act, though they are based only on a partial knowledge of the laws of spread of this poison.

These indications are—

1. The portability of the disease, *i.e.*, the carriage of cholera from one place to another by persons ill with the disease, both in the earliest stage (the so-called premonitory diarrhœa), and the latter period, and in convalescence.[3] The carriage by healthy persons coming from infected districts is not so certain; but there is some evidence.[4] It is clear this last point is a most important one, in which it is desirable to have more complete evidence. The occasional carriage by soiled clothes, though not on the whole common, has also evidence in its favor. All these points were affirmed by the Vienna Conference of 1874. Even Pettenkofer admitted that man is the carrier of the disease germ, although the *locality* may be the means of rendering it potent. On the other hand, Dr. J. M. Cuningham[5] makes a *tabula rasa* of everything, denies the transportability of the disease either by persons or by water, and says there is a mysterious factor still to be sought for. His evidence, however, cannot be considered as conclusive.

Whatever may be the final opinion on all these points, we are bound to act as if they were perfectly ascertained. It is usually impossible to have rigid quarantines; for nothing short of absolute non-communication would be useful, and this is impossible except in exceptional cases. For persons very slightly ill, or who have the disease in them but are not yet apparently ill, or possibly who are not and will not be ill at all, can give the disease, and therefore a selection of dangerous persons cannot be made. Then as the incubative stage can certainly last for ten or twelve days, and there are some good cases on record where it has lasted for more than twenty, it is clear that quarantine, unless enforced for at least the last period of time,

[1] The researches of Lewis and D. D. Cunningham in India, and of Eberth, of Zürich (Zur Kenntniss der Bacteritischen Mykosen, von J. C. Eberth, 1873), have shown that no specific germ has been yet discovered, and have disproved the fungoid and other origins proposed by Hallier, etc.

[2] There is, of course, no doubt that the common autumnal cholera, however much it may resemble superficially the Indian cholera, is quite a separate disease.

[3] With respect to convalescence, the only evidence is apparently that given by Volz, quoted by Hirsch, Jahresb. für ges. Med., 1868, Band ii., p. 221.

[4] Especially in the Mauritius outbreaks, where parties of coolies coming from places where cholera prevailed, but being themselves healthy, gave cholera to other parties of coolies who had arrived from India, and had no disease among them. Dr. Leith Adams (Army Medical Report, vol. vi., p. 348), in his excellent Report on Cholera in Malta, states: "There are many pointed facts to show that cholera may be introduced and communicated to susceptible persons by healthy individuals from infected districts."

[5] Ninth Annual Report of the Sanitary Commissioner with the Government of India.

may be useless. The constant evasions also of the most strict cordon render such plans always useless. An island, or an inland village, far removed from commerce, and capable for a time of doing without it, may practise quarantine and preserve itself; but, in other circumstances, both theory and actual experience show that quarantine fails.[1] M. Fauvel [2] believes that the quarantine measures adopted in the Red Sea have been instrumental in preventing the spread of cholera to Europe on three separate occasions, namely, 1872, 1877, and 1881.

This difficulty, however, of carrying out efficient isolation is no argument against taking every precaution against communication, and keeping a strict watch and control over every possible channel of introduction. In this way, by isolation of the individual, or of bodies of men, as far as possible, and by looking out for and dealing with the earliest case, an outbreak may perhaps be checked, especially by discovering the diarrhœal attacks, and by using disinfectants both to the discharges and to linen.[3] In the case of troops coming from infected districts they should be kept in separate buildings for twenty days, and ordered to use only the latrines attached to them, in which disinfectants should be freely used.

2. The introduction of the disease into any place by persons is considered by most observers to be connected with the choleraic discharges, either when newly passed, or, according to some, when decomposing. The reasons for this are briefly these: the portability being certain, the thing carried is more likely to be in the discharges from the stomach and bowels than from the skin or breath (the urine is out of the question), and for these reasons: Water can communicate the disease, and this could only be by contamination with the discharges; water contaminated by discharges has actually given the disease, as in Dr. Macnamara's cases; in some cases a singularly local origin is proved, and this is nearly always a latrine, sewer, or receptacle of discharges, or a soil impregnated with choleraic evacuations; soiled linen has sometimes given it, and this is far more likely to be from discharges than from the perspiration; animals (white mice and rabbits) have had cholera produced in them from feeding on the dried discharges. Finally, in the history of the portability of cholera, there are many instances in which, while there has been decided introduction by a diseased person into a place, there has been no immediate relation between that person and the next case; in other words, the cause must be completely detachable from the first case, and must be able to act at a distance from his body; it is therefore far more probable that the discharges are this

[1] When circumstances are favorable (as respects trade and intercourse), however, good quarantine may be successful even on the mainland. This was shown in Algeria in 1861. See Dr. Dukerley's Notice sur les Mesures de Préservation prises à Batna (Algérie) pendant le Choléra de 1867, Paris, 1868, for a very interesting account of those successful measures of which strict isolation and constant hygienic measures were the principal. So also in America, Dr. Woodward states (Circular on Cholera, No. 5, Surgeon-General's Office, Washington, 1867) that "the general tenor of army experience is strongly in favor of quarantine." Quarantine on land was condemned by the Vienna Conference, but recommended on the Red Sea and the Caspian. In Europe, however, only rigorous inspection was recommended, with various rules for preventing spread as much as possible.

[2] Revue d'Hygiène, vol. iv., 1882, p. 754.

[3] The Indian Government are now cautiously attempting to limit the spread of cholera by superintending and controlling the pilgrimages, which are so common a cause of the spread of cholera in India. The Report of the Cholera Committee (Inspector-General Mackenzie, Colonel Silva, and Dr. Ranking) to the Madras Government, published at Madras in 1868, gives a great deal of important evidence on this point, and in addition lays down excellent rules for the management of pilgrimages.

carrying agency, than that any effluvia should pass off from the lungs and skin which could spread to a great distance.

Enough has been said to show that the discharges must receive the most careful attention. Every discharge ought to be disinfected with strong substances liberally used ; the best are carbolic acid (in large quantity), perchloride of iron, chloride of zinc, chloride of lime, or, if none of these are at hand, good quicklime. Although the results of disinfection of the discharges have not hitherto been encouraging, the plan has seldom been completely tried. All latrines should be disinfected, sewers flushed, carbolic acid poured down them, and every means taken to keep them ventilated.

What should be done with the disinfected discharges? Should they be allowed to pass into sewers, or buried in the ground? They must in some way be got rid of. Sewers certainly afford an easy mode of disposing of them ; and as the discharges are mixed with much water, and are rapidly swept away in them, and as the temperature of the sewers is low, and decomposition is delayed, it is quite possible that sewers may be a means of freeing a town from choleraic discharges more easily than any other plan. And it appears to be a fact, that in the well-sewered towns in England the cholera of 1865 and 1866 never attained any wide spread. In Munich, in the cholera epidemic of 1873, the well-sewered parts of the town had only one-half the sickness and mortality of the others, which were either imperfectly drained or not at all.[1] In large towns, also, there are no other means of disposing of the discharges. But may not sewers be a means of dissemination,[2] and thus, as in some outbreaks of enteric fever, be a source of danger? And again, when sewerage is poured over land, as it will be soon throughout all England, are we quite sure that no choleraic effluvia will pass off, or that the choleraic particles passing into the ground may not develop there, as Pettenkofer supposes is the case? There are no facts to enable us to decide, but the possibility of mischief arising in this way should, at any rate, make us still more urgent in the use of disinfectants to all discharges.

Again, as to disposal in the earth, if Pettenkofer is correct, that a loose moist earth is the place where the supposed germ of cholera acquires its power, the last place we should put a choleraic discharge would be the earth ; and there would be even an argument against the use of the earth plan of dealing with sewage. Still, as there is much to be said against Pettenkofer's views, and as in small towns and villages there is only the alternative of allowing the discharges to pass into cesspools or streams, or to be disposed of in the earth, it would seem to be the safest course to deeply bury all disinfected discharges, care being taken to place them at a distance from houses and from sources of water supply. Another plan would be to mix them with sawdust and burn them.

That linen and bedding should be carefully disinfected, needs no argument. In some English towns all cholera clothing has been burnt, but whether this measure is necessary or not is uncertain. But thorough steeping and boiling before washing is essential, as washerwomen have certainly suffered in many cases.

3. The introduction of the agent by the medium of the air is generally

[1] Soyka, Deutsche Viertlj. f. Off. Ges., Band xiv., Heft 1, p. 54, 1882.

[2] That these may be so, in a particular way, was shown to be probable in Dr. Parkes' Report on Cholera in Southampton (Sixth Report of the Medical Officer to the Privy Council, p. 251); but still there is very little evidence on this point.

admitted, on the plea that cases occur in which any other mode of entrance is impossible. It is also held by some that, existing in the air, it can be carried for great distances by winds ; and some observers indeed believe this to be its usual mode of transit, though this opinion appears opposed to all we know of its spread.

Without attempting to decide the point or to state the limits of the transmission, it is a matter of prudence to act as if the winds did carry the poison. The Indian rule is to march at right angles to the wind, and never against it or with it if it can be avoided. The spreading by the winds in India has been usually ascribed to the custom of throwing all the cholera evacuations on the ground ; there they get dried, and then are lifted by the wind and driven to other parts. This seems probable, but no decided proof has been given ; and an argument against it may be raised on the difficulty of accounting for the immunity of adjacent places if such transmission were common. So also the use of aërial disinfectants in cholera is rendered imperative by the chance that the cause may be in the air. The use of sulphur fires has been advocated and tried in India, apparently with good effect (Crerar). The Vienna Conference affirmed transmission by the air, but only to a short distance, and never faster than man travels. They also recognized the great safeguard afforded by deserts, as the disease has never been known to be imported into Egypt or Syria across the desert by caravans from Mecca.[1]

4. The occasional, perhaps frequent, introduction by water seems certain. It was unanimously affirmed at the Vienna Conference, even by Pettenkofer, who has, however, since abandoned this view. It is a good plan always to change the source of supply, to use rain-water if no other fresh source is procurable ; and in every case to boil, and filter, and to use also potassium permanganate.[2] It remains yet uncertain whether a water which gives cholera is always chemically impure, or whether the choleraic matter may be in so small a quantity as to be absolutely indetectable. In the two cases examined by Dr. Parkes in which the water was the cause, it was highly impure. In India it is now ordered that all the water should be boiled.[3]

5. The introduction by food has been noted in some cases (although the Vienna Conference decided, by 11 to 7, that present facts do not warrant a decision). Every article of food, solid and liquid, should therefore be passed in review, and the cooking arrangements gone over step by step.[4]

[1] On this point the history of Chili is interesting, as cholera has never reached it. It is separated on the north from Peru by the desert of Attacama, and from the Argentine Confederation on the east by the Andes range, to which circumstances its immunity hitherto from epidemic diseases has been ascribed by the inhabitants.

[2] In the very able Report on Epidemic Cholera in the United States Army (Circular No. 5, War Department; Surgeon-General's Office, Washington), is what appears to be a good instance of the effect of changing the supply. At New Orleans rain, and in some cases distilled water, was supplied instead of river water, with the apparent effect of checking the spread (p. xvii.); see also the cases of Utrecht and Rotterdam, as reported by Buys-Ballot.

[3] G. O. C. C., No. 192, clause 53. Förster, of Breslau (Die Verbreitung der Cholera durch die Brunnen, 1873), urges two recommendations which he thinks will prevent cholera in the future—1st, Lead to every town, even if at great cost, abundant and pure water, as indeed was done, he says, much better 2,000 years ago than now. 2d, Protect the ground from contamination in any way from excrement, and banish all cesspits. The ground must be absolutely pure, and this can only be if all fecal matter is removed to a distance.

[4] See Dr. Fairweather's Delhi case in the Sanitary Report of the Punjab for 1871 ; also given in Report on Hygiene, in the Army Medical Report, vol. xiii. (1873).

6. The localization of cholera is a marked feature in its history.[1] It is often as marked as in yellow fever, and may be confined to a very small area. At other times, in India, the "tainted district" may be of some extent. From this fact of localization arises the important rule of always leaving the locality when practicable, and in a large town of clearing out the house where cholera has happened. In India the present rule is to march the men out and encamp in a healthy spot at some little distance, changing the encamping ground from time to time. On the whole, this has acted well, and should be adhered to, though occasionally it has failed, generally, however, it would seem, from error in choice of locality. The men should be tented; the tents should be well ventilated, and often struck and repitched; an elevated spot should be chosen, and damp and low soils and river banks avoided. Orders lay down with precision the exact steps to be taken by a regiment when cholera threatens.[2] This rule of marching out must, of course, be subject to some exceptions. It has been advised that it should not be done in the rainy season in India. This must depend on the locality. It appears sometimes to have answered well, even in heavy rains; but in other cases the rains may be too heavy. No absolute rule can be laid down; but the circumstances which are allowed to set aside the grand rule of evacuation of a tainted place should be unequivocal.

In connection with change of locality, the opinions of Pettenkofer should be borne in mind. Pettenkofer believes that, of all conditions, the effect of soil is the most important. It is necessary, then, to consider particularly the nature of the soil where the fresh camps are to be placed, and to select perfectly dry and, if possible, pure, impermeable, uncontaminated soils, and to prevent the cholera discharges from percolating through the ground.

7. Men sick from cholera are also best treated in well-ventilated tents, whenever the season admits of it. Even in cold countries, up to the end of October or the middle of November, tents can be used if properly warmed. In India it should be a rule to treat every cholera patient in a tent, as far as circumstances permit it.

Internal Causes.—General feebleness of health gives no predisposition, nor is robust health a safeguard; some even have thought that the strongest men suffer most. Great fatigue, and especially if continued from day to day, greatly predisposes; of this there seems no doubt.[3] No certain influence has yet been traced to diet, although it has been supposed that a vegetable diet and alkalinity of the intestinal contents may predispose. It

[1] Surgeon P. Cullen (Indian Medical Gazette, July 1, 1873) notices a very singular case of localization at Etarsi.

[2] The order in India is, if a single case occur in a barrack, to vacate that part of the barrack, and to encamp the men in the cantonment. If a second case occur among the body of men thus removed, they are again moved, and the building or tent is vacated and purified. If a third case occur in this body of men within a week, they are removed to the preparatory camp.

Buildings are purified by scraping and washing walls with hot caustic limewash; boiling punkah fringes, ropes, curtains, etc., and using chloride of lime or other disinfectant. Tents are purified by being fumigated with either chlorine, nitrous acid, or sulphurous acid, and then exposed to the weather for ten days. Railway carriages, after occupation by troops carrying cholera, are purified by washing with boiling water containing in each gallon a wineglassful of carbolic acid, and burning sulphur in the closed carriages for two hours. If troops are moved by rail, they are not to use latrines, but trenches are to be dug for them (G. O. C. C., No. 193).

[3] There are many instances of the effects of long marches. See Orton, Lorimer, and Thom, quoted in Brit. and For. Med. Chir. Rev., July, 1848, pp. 85–87.

does not appear that insufficient diet has any great effect, though there is some slight evidence that scurvy increases the mortality, and perhaps the predisposition.[1] The strictest temperance does not preserve from attacks; but every one agrees that spirits are no protection, and that debauchery increases liability.

Of pre-existing diseases, it has been supposed that cardiac affections and pulmonary emphysema predispose; the evidence is very unsatisfactory. If Beale's observations be correct, post-mortem examinations often show previous affection of the villi and mucous membranes of the intestines generally; but it is very desirable there should be more proof of this.

Diarrhœa predisposes, and any causes which lead to diarrhœa, especially impure water, dietetic errors, etc., should be carefully looked after.

With regard to prophylactic measures (except in respect to proper diet, free ventilation, and pure water) nothing has yet been made out. Quinine has been recommended, and should certainly be given, especially in malarious countries, as it is a fact that the choleraic poison and malaria may act together, and even give a slight periodical character to choleraic attacks, which is never seen in non-malarious districts, and is therefore merely grafted on cholera. Peppers, spices, etc., have been used; but there is no good evidence respecting them. All diarrhœa should be immediately checked, and this is well known to be the most important point connected with the prevention of the internal causes. The universal order in India is, that any man going twice in one day to the latrine should report himself; and non-commissioned officers are usually stationed at the latrines to watch the men. The reason of this rule should be fully explained to the men. In two attacks of cholera in India, Dr. Parkes found it almost impossible to get the men to report themselves properly; the slight diarrhœa of early cholera is so painless that they think nothing of it.[2] In England and Germany house-to-house visitation has been found very useful.[3]

[1] For some evidence as to scurvy, see Pearce and Shaw "On the Cholera of the Jail at Calicut," Madras Medical Journal, July, 1863.

[2] Several points have been taken from Mr. Dickinson's useful little pamphlet on the Hygiene of Indian Cholera, 1863.

[3] Great importance has been attached to the meteorological condition attending outbreaks of cholera; they do not appear to be very important, except in two or three cases.

1. *Temperature.*—A high temperature favors the spread by increasing the putrefaction of the stools, and by augmenting generally the impurity of the air. When cholera has prevailed at a low temperature (it has been severe at a temperature below freezing), the drinking-water has possibly been the cause.

2. *Pressure* has no effect. The old observation of Prout, that the air is heavier in cholera epidemics, has never been confirmed.

3. *Moisture in Air.*—Combined with heat, this seems an accessory cause of importance, probably by aiding transmission. Moisture in the ground, combined with heat of the soil, has always been recognized as an aiding cause of great importance.

4. *Dryness of Air* seems decidedly to check it.

5. *Rain* sometimes augments, sometimes checks it. This, perhaps, depends on the amount of rain, and on whether it renders the drinking-water more or less pure. A very heavy rain is a great purifier.

6. *Movement of Air.*—It is certainly worst in the stagnant atmospheres, as in the cases of all the specific poisons.

7. *Electricity* is not known to have any effect. This was particularly examined by Mr. Lamont in Munich, one of the most celebrated physical philosophers of our time, but with entirely negative results.

8. *Ozone* has no effect, either in its presence or absence (Schultze, Voltotine, De Wethe, Lamont, Strambio, Wunderlich).

Typhus Exanthematicus (*Spotted Typhus*).

External Cause.—An animal poison, origin unknown, but communicable from person to person, probably through the excretions of the skin and lungs floating in the air. Not known to be communicated by water or food. Its spread and its fatality are evidently connected with overcrowding and debility of body from deficient food. That it can be produced by overcrowding is yet uncertain.[1] The preventive measures may be thus shortly summed up: Adopt isolation[2] of patients; use the freest ventilation (5,000 to 6,000 cubic feet per head per hour or more); evolve nitrous acid and chlorine fumes; thoroughly fumigate with sulphurous acid, heat (to 220° Fahr.), wash, and expose to air all bedding (including mattresses) and clothes. This last point is extremely important. In fact, it may be said that, for the prevention as well as treatment of typhus, the cardinal measures are abundance of pure air and pure water. Whenever practicable, treat all typhus patients in tents, or wooden huts with badly joined walls, not in hospitals. Fumigate tents and scrape and limewash huts, and remove earth from time to time from the floors. A number of typhus patients should never be aggregated; they must be dispersed; and if cases begin to spread in an hospital, clear the ward, and then, if the disease continues, the hospital itself; then wash with chloride of lime, and then limewash or scrape walls and floors, and thoroughly fumigate with nitrous acid. It has been often shown that even exposure to weather, bad diet, and insufficient attendance are less dangerous to the patients than the aggregation of cases of typhus.

Internal Causes.—A special condition of body is necessary, as in the case of small-pox, and one attack protects to a great extent from another. The nature of the internal condition is unknown; but general feebleness from bad diet, overwork, exhaustion, and especially the scorbutic taint, greatly increase the intensity of the disease in the individual, and perhaps aid its spread. These conditions, then, must be avoided. But the strongest and best health is no guarantee against an attack of typhus.

Bubo or Oriental Plague (*Pali Plague in India*).[3]

The preventive measures should be the same as in typhus, to which this disease shows great analogy. The history of the plague at Cairo (from which it has been now banished for many years, simply by improving the

[1] During the French war of 1870, although there was much crowding, wretchedness, and misery in Paris, and particularly in Metz, there was but little typhus; it was nothing like the amount in the first Napoleon's time (Grellois, Histoire Médicale du Blocus de Metz, 1872, Chauffard, Académie de Médecine).

[2] By the term isolation is meant the placing a patient in a separate building, not in another room in the same building; in the case of small-pox, typhus, and scarlet fever, this partial isolation, though sometimes successful, cannot be depended upon. If a room must be chosen in the same building, choose the top story, if a room can be there found.

[3] The Pali plague (Maha Murree), which was most common in Rajpootana, was evidently propagated by the filthy habits of the inhabitants (see Ranken and others), and was some years ago almost entirely got rid of by sanitary measures. Subsequently, these were neglected, and the disease returned. It has now again greatly lessened. Hirsch has pointed out that the Pali plague differs from the Egyptian plague in having a marked lung disease, and in this it resembles the black death in the fourteenth century, with which Hirsch, in fact, considers it identical.

ventilation of the city),[1] and the disappearance, after sanitary improvements, of the Pali plague in India, and its recurrence on the cessation of preventive measures, show that, like typhus, the bubo plague is easily preventible. Elevation, as in so many other specific diseases, has a considerable effect; the village of Alum Dagh, near Constantinople (1,640 feet above the sea), and freely ventilated, has never been attacked; the elevated citadel of Cairo has generally been spared; and when Barcelona was attacked, the elevated citadel also escaped.

Typhoid or Enteric Fever.

External Cause.—A poison of animal origin; one mode of propagation is by the intestinal discharges of persons sick of the disease; other modes of origin and transmission are not disproved. There is doubtless a frequent transmission of the disease by the diarrhœa of mild cases which are often not diagnosed. There is some evidence that persons considered convalescent may carry the disease,[2] but it is possible that this may have been owing to badly washed clothes. The mode of entrance into the body is both by air and water. Entrance by food (milk) has been lately also proved. As means of arresting the disease, isolate the patients; receive all evacuations (fæces and urine) into the vessels strictly kept for one sick person; place zinc chloride, or ferrous sulphate, or carbolic acid, etc., in the vessels; never empty any evacuation into a closet, sewer, or cesspool; bury it several feet deep, and mix it well with earth. Fumigate, and heat to 220° Fahr., all clothes and bedding. As means of prevention, attend especially to the purity of the drinking water, and to the disposal of sewage; although the origin of typhoid merely from putrefying non-typhoid sewage is not considered at present to be probable, it is not disproved, and it is certain that the disease may spread by the agency of sewers and fecal decomposition. A single case of typhoid fever should at once be held to prove that something is wrong with the mode of getting rid of the excretions. If neither water nor sewers can be proved to be in fault, consider the milk and other food supply.

Internal Causes.—As a first attack preserves in a great measure from a second, a peculiar condition of body is as essential as in small-pox; and looking to the special effect produced on Peyer's patches, and to the fact that at the period of life when these patches naturally degenerate, the susceptibility to typhoid fever materially lessens, or even ceases, it seems possible that the internal cause or necessary second condition is the existence of these patches, the structures in which are brought into an abnormal state of activity by the direct or indirect action of the poison on them. The other internal causes are anything which causes gastro-intestinal disorder, such as bad water, and general feebleness.

Relapsing Fever.

No preventive measures have been yet pointed out, but the occurrence of the disease in times of famine seems to indicate that feebleness and inanition are necessary internal causes.

[1] Stamm, in Pappenheim's Beiträge, 1862–63, p. 80. The measures adopted in Cairo were levelling some hillocks, which stopped the air from blowing over the city, filling up some marshes, and adopting a better mode of burial. The peculiar sepulture customs of the Copts have indeed even been assigned as the sole cause of the origin of plague.

[2] Gietl., Die Ursachen der enterischen Typhus in München, 1865, pp. 74 and 94.

Bilious Remittent Fevers.

Under this vague term, a disease or diseases, which in many points are like relapsing fever, but yet are not identical (Marston), have been described as occurring especially in Egypt (Griesinger), and in the Levant generally. It has also been described by Drs. Marston and Boileau,[1] at Malta. The exact causes are not known; but in some of the writings of the older army surgeons, the fevers which are produced by foul camps (in addition to typhoid) appear to have a close resemblance to the bilious remittent fevers of the Mediterranean. They appear to be connected with bad sanitary conditions, but their exact causation is not clear.

Cerebro-Spinal Meningitis.

This disease, which has occasionally been noticed in France, and especially among soldiers, for the last half century, has within late years appeared in several parts of Germany, and a few cases among civilians have occurred in England. It seems to depend on a specific agent, but very little is yet known about it. It does not appear to be contagious. No preventive measures can be at present suggested.

The Eruptive Fevers.

Small-pox is guarded against in the army by repeating vaccination in the case of recruits, and by occasional re-vaccination of all the men in a regiment. In the statistical reports, great attention is always paid to this important point, and the evidence from foreign armies proves the necessity of careful re-vaccination.

If the disease does occur, isolation[2] (in separate buildings) is most important, but the aggregating of a large number of cases together ought to be avoided.

In the case of scarlet fever and measles, nothing definite is known with regard to prevention, except that a good sanitary condition seems to lessen their intensity, and probably their spread. The evidence with regard to belladonna in scarlet fever is contradictory, but on the whole unfavorable. All the discharges should be disinfected, and the skin well rubbed over with camphorated oil and a little weak carbolic acid.

The most difficult case is when either measles or scarlet fever appears on board ship, and especially if children are on board. If the weather permit, the best plan is then to treat all patients on the upper deck under an awning. If this cannot be done (and scarlet fever patients must not be exposed to cold), they must be isolated as much as possible. Both in scarlet fever and small-pox there is some evidence to show that the incubative period may be very long.[3]

Perhaps, in the present state of evidence, it might be desirable to try the prophylactic effects of belladonna on board ship, directly the first case occurs.

[1] Army Med. Reports, vols. iii. and viii.

[2] Buchanan gives a good example of the advantages of isolation in the case of Cheltenham, where small-pox was introduced into the town six times, but, in consequence of proper hospital accommodation for *all* classes, never made good its footing.

[3] See a case by Bryson (Trans. Soc Science Assoc., 1862, p. 677), for a case in which the incubative period of small-pox appeared to be thirty-one days. In scarlet fever it is said to be sometimes even longer.

Erysipelas (Hospital or Epidemic).

External Cause.—It is well known that in the surgical wards of hospitals erysipelas occasionally occurs, and then may be transmitted from patient to patient. The exact causes of its appearance have not been made out, but it is evidently connected with overcrowding and impure air. Moisture of the floors, causing constant great humidity of air, has also been supposed to aid it. It is much more common in fixed hospitals than in tents and huts, and indeed is exceedingly rare in the two latter cases. The agencies or agent can scarcely be supposed to be other than putrefying organic matter and pus-cells passing into and accumulating in the air, or organisms developed in connection with them. It is remarkable that pus-cells derived from purulent sputa do not cause erysipelas in medical wards, but this may be from a want of open wounds to give the necessary personal condition.

When hospital erysipelas has once appeared in a ward, nothing will avail except complete clearance of the ward, scraping the floors, and often the walls, washing with chloride of lime, and then with solution of caustic lime, and thorough fumigation with chlorine and nitrous acid alternately. The erysipelatous cases should be placed in well-ventilated tents.

Considering the undoubted beneficial influence of tent life, it may be a question whether, even in civil life, hospitals which possess gardens should not, during the summer, treat their surgical cases with suppurating wounds in the tents.[1] In many continental towns the large hospitals have now wooden huts attached to them, in which the surgical cases are treated.

Of course, extreme care in conservancy of wards or tents, the immediate removal of all dressings, great care in dressing wounds, so that neither by instruments, sponges, lint, or other appliances, pus-cells or molecular organic matter shall be inoculated, are matters of familiar hospital hygiene. The use of carbolic acid and other antiseptics, as introduced by Professor Lister, will, it is hoped, greatly lessen the chances of spread in the case of erysipelas as well as of hospital gangrene.[2]

Internal Causes.—Nothing is known on this point, except that there must be some abrasion or wound of the surface or of the passages near the surface, as the vagina or throat. The erysipelas commences at the point of abrasion. If there is no open wound, the atmospheric impurity seems to have no bad effect on the persons who are exposed to it, but it would be interesting to know if some forms of internal disease are not produced. Is it possible that some forms of tonsillitis and diphtheritic-like inflammation of the throat may be caused in this way, although there is no solution of continuity?

Hospital Gangrene.

Almost the same remarks apply to hospital gangrene as to erysipelas. One of the most important facts, which has been pointed out by many writers, and which has been thoroughly proved by the American and the Italian wars, is that perfectly free ventilation prevents hospital gangrene. Hammond, the late Surgeon-General of the United States Army, declares[3]

[1] See Hammond's Hygiene, 1863; Kraus' Das Kranken und Zerstreuungs-System, 1861; and a Report on Hygiene, by Dr. Parkes, in the Army Medical Report for 1862, for the effects of tents on erysipelas and hospital gangrene.

[2] I was informed, in Munich, that Lister's system has completely banished hospital gangrene from that city, and I believe the same result has been noticed in other German towns.—(F. de C.)

[3] Hygiene, p. 397.

that only one instance has come to his knowledge in which hospital gangrene has originated in a wooden pavilion hospital, and not one which has occurred in a tent. Kraus also, from the experience of the Austrians in 1859, states that it never could be discovered that gangrene originated in a tent. On the contrary cases of gangrene at once commence to improve when sent from hospital wards into tents. On the other hand, the tenacity with which the organic matters causing the gangrene adhere to walls is well known.

The measures to be adopted in wards when hospital gangrene occurs, and the ward cannot be at once evacuated, are the same as for erysipelas.[1] It is not necessary to do more than allude to the undoubted transference by dirty sponges, etc., and to the beneficial effects of antiseptic dressings.

SECTION II.

VARIOUS NON-SPECIFIC DISEASES.

Dysentery and Diarrhœa.

At present there is no evidence that the dysentery arising from various causes has different anatomical characters, or runs a different course, except perhaps in the case of malarious dysentery. The chief causes are—

1. *Impure Water.*—Both Annesley and Twining have directed attention to this cause, in their accounts of Indian dysentery. It is scarcely possible that, with common attention, this cause should not be discovered and removed.

2. *Impure Air.*—The production of dysentery and diarrhœa from the effluvia of putrefying animal substances is an opinion as old as Cullen, and probably older; and there seems little doubt of its correctness. The gases and vapors from sewers also will, in some persons, cause diarrhœa; and also effluvia from the foul bilge-water of ships.[2] On the other hand, very disagreeable effluvia from many animal substances, as in the case of bone-burners, fat-boilers, etc., do not seem to cause diarrhœa. In India there appears to be a decided relation between the prevalence of dysentery and overcrowding and want of ventilation in barracks; massing a large number of men together is certainly an accessory cause of great weight.[3]

The air from very foul latrines has caused dysentery in numerous cases. Pringle, and many other army surgeons, record cases.[4] In war this is one of the most common causes. The occasional production of dysentery from sewage applied to land, seems to be proved by Clouston's observations on

[1] With regard to pyæmia, observations show that one of the external causes is fetid organic emanations. Spencer Wells (Med. Times and Gazette, 1862) states, that in 1859 the mortality from pyæmia was great in some wards over a dissecting-room. On removing all the cases after operation to the opposite side of the building, pyæmia almost disappeared. Other similar cases are on record.

[2] Fonssagrives (Traité d'Hygiène Navale, p. 60) records a good case of this kind. It commenced after a gale at sea had stirred up the bilge, and on clearing it out the attack ceased.

[3] Wood on the Health of European Soldiers in India, 1864, p. 45 et seq.

[4] Sir James M'Grigor, Vignes (who give many cases from the French experience in the Peninsula), Chomel, Copland; see also the Dic. des Sciences Méd., art. "Dysentérie." D'Arcet (Ann. d'Hygiène, vol. xii., p. 390) records a good case, in which a whole regiment was affected in the Hanoverian war, from having used too long the same trench as a latrine. The disease disappeared when another was dug.

the cause of the attack of dysentery in the Cumberland Asylum.[1] Still sewage matter has been often applied in this way without bad effects. In Dr. Clouston's case the sewage was 300 yards from the ward where the dysentery occurred. Calm and nearly stagnant nights, or with a *gentle* movement of air from the sewage toward the ward, were the conditions which preceded most of the attacks.

Of all the organic effluvia, those from the dysenteric stools appear to be the worst. Some evidence has been given to show that dysentery arising from a simple cause (as from exposure to cold and wet), when it takes on the gangrenous form, and the evacuations are very fetid, produces dysentery in those who use the latrines, or unclean closets, into which such gangrenous evacuations are passed. If correct, this is a most interesting point, as it seems to show the origin of a communicable poison *de novo*. Possibly, in all these cases, effluvia, or organic matters, or particles disengaged from the putrefying evacuations, act at once on the anus, and the disease then spreads up by continuity.

There is some reason, also, to think that retaining dysenteric stools in hospital wards spreads the disease; and, perhaps, in this case, the organic particles floating up may be swallowed, and then act on the mucous membrane of the colon. In the epidemic of dysentery in Sweden in 1859, there was good evidence to show that it spread by means of the diarrhœal and dysenteric evacuations.[2] In all cases the stools must be mixed with disinfectants, and immediately removed from the wards and buried.

3. *Improper Food.*—Any excess in quantity, and many alterations in quality (especially commencing decomposition in the albuminates, and, perhaps, the rancidity of the fatty substances) cause diarrhœa, which will pass into dysentery. But the most important point in this direction is the production of scorbutic dysentery. A scorbutic taint plays a far more important part in the production of dysentery than is usually imagined, and there is now no doubt that the fatal dysentery, which formerly was so prevalent in the West Indies, was of this kind. Much of the Indian dysentery is also often scorbutic.

4. *Exposure to Cold and Wet.*—Exposure to cold, especially after exertion, and extreme variations of temperature, have been assigned as the chief cause of dysentery by numerous writers;[3] great moisture has been assigned by some writers (Twining, Annesley, Griesinger) as a cause; and great dryness of the air by others (Mouat); while a third class of observers have considered the amount of moisture as quite immaterial.

Hirsch,[4] after summing up the evidence with respect to the temperature with great care, decides that sudden cold after great heat is merely a "*causa occasionalis*"[5] which may aid the action of the more potent cause

[1] Medical Times and Gazette, June, 1865.

[2] British and Foreign Med. Chir. Rev., January, 1866, p. 140.

[3] A few only can be noted; Stall, Zimmermann, Huxham, Durandeau, Willan, Irvine, James Johnson, Annesley, Bampfield, Morehead, Vignes, Fergusson, etc. Fergusson says: "True dysentery is the offspring of heat and moisture; of moist cold in any shape after excessive heat. Nothing that a man can put into him would ever give him true dysentery."

[4] Handbuch der Historisch-Geograph. Pathol., Band ii., p. 234.

[5] The so-called "hill diarrhœa," which was formerly prevalent on some of the hill sanitaria in India, especially on the spurs of the Himalayas, has been attributed to the effect of cold and moisture, and sudden changes of temperature. But, as remarked by Dr. Alexander Grant, many hill stations have these atmospheric conditions without having any hill diarrhœa. There is great reason to suppose the hill diarrhœa to be entirely unconnected with either elevation or climate. In some cases it has been

of dysentery. This, probably, is the true reading of the facts. The amount of moisture in the atmosphere would appear to be a matter of no moment.

Although we cannot assign its exact causative value, the occurrence of chill is, of course, as a matter of prudence, to be carefully guarded against; and especially chills after exertion. It is when the body is profusely perspiring, and is then exposed to cold, that dysentery is either produced, or that other causes are aided in their action. In almost all hot countries chilling of the abdomen is considered particularly hurtful, and shawls and waist-bands (kummerbund of India) are usually worn.[1]

5. *Malaria* has been assigned as another cause; and it was noticed especially by the older writers, that the dysentery was then often of the kind termed "*Dysenteria Incruenta*"—the stools being copious, serous, and with little blood; in fact, a state somewhat resembling cholera.

Very great difference of opinion has prevailed in regard to this opinion.[2] Possibly the "malarious dysentery" is in part connected with the use of marsh water. More evidence is desirable, certainly, with regard to this point; but it seems probable, from the observations of Annesley and Twining, that marsh water has an effect in this direction.

Liver Diseases (Indian).

The production of diseases of the liver is so obscure, and so many states of hepatic disorder are put together under the term "hepatitis," that it is impossible to treat this subject properly without entering fully into the question of causes. But, as this could not be done here, we must content ourselves with a short summary of the preventive measures which appear to be of the greatest importance.

Dr. Parkes had long been convinced that many cases of hyperæmia, bilious congestion, and enlargement of the liver, with increase of cell-growth and connective tissue (but without tendency to abscess), and enlargement and partial fatty degeneration of the liver-cells, are caused simply by diet.[3] He had a good opportunity of observing this on landing in India in 1842 with an European regiment,[4] and his later experience made him certain that the observation was correct.

clearly caused by bad water, possibly by suspended scales of mica or by magnesian salts in the water; in other cases, its exact causes remained unexplained. Of late years it has lessened in amount at all stations, and will probably disappear.

[1] It is a remarkable circumstance, that in temperate climates the most common months for dysenteric epidemics are the hot months—June to September. Taking North America and Northern and Western Europe, Hirsch has assembled 546 outbreaks. Of these, 176 occurred in summer; 228 in summer and autumn; 107 in autumn; only 16 in spring; and 19 in winter. This does not look as if cold had any effect. The heat of summer is far more influential.

[2] The very varying opinions are given very fully by Hirsch. Morehead's great authority was altogether against the presumed action of malaria; but possibly here, as in many other cases, we shall have to draw a complete distinction between malarious and non-malarious dysentery.

[3] In the great and admirable works of Ranald Martin and Morehead, the influence of diet in producing liver affections, though alluded to, has been passed over much too lightly. Annesley, on the other hand, has fully recognized the immense influence of diet (vol. i., p. 192).

[4] Remarks on the Dysentery and Hepatitis of India, by E. A. Parkes, M.B., 1846, p. 228.

Very similar opinions have been expressed by Macnamara,[1] and Norman Chevers has also pointedly alluded to this subject.[2]

The supply of food for the soldier in India has erred in two ways: it is too much in quantity, especially when the amount of exercise is limited. Macnamara has calculated that each European soldier in Bengal consumed (at the time he wrote, in 1855) 76 ounces of solid (*i.e.*, water-containing) food daily, so that there must have been an excess of all the dietetic principles. Then, in every case, there was added to this a very large amount of condiments (spices and peppers), articles of diet which are fitted for the rice and vegetable diet of the Hindu, but are particularly objectionable for Europeans. In the West Indies, where the diet has never been so rich in condiments, liver diseases have always been comparatively infrequent.

Some orders for improving the cooking in India were issued by Lord Strathnairn, and if these were carried out, and if medical officers would thoroughly investigate the quantity of food taken by the men, and compare it with their work, and examine into the cooking, it is quite certain that many cases of dyspepsia and hepatitis would be prevented.

In cases not simply of hyperæmia and bilious congestion, but of abscess, it is probable that a certain number are consecutive to dysentery, and are caused by the absorption of putrid matters from the intestine,[3] which are arrested by the liver, and there set up suppuration. There is no true pyæmia or inflammation of the vena portæ as a rule. When caused by phlebitis or special affection of the vena portæ, the suppuration is in the course of the vena portæ, or at any rate commences there. The reason why some cases of dysentery cause abscess and others do not, is uncertain. The prevention of this form of abscess is involved in the prevention of dysentery.

In other cases of abscess, however, there is no antecedent dysentery, but there are collections of pus or fetid débris somewhere else, which act in the same way by allowing absorption. There are, however, other cases in which no such causes have been pointed out, and the genesis of these cases of abscess remains quite obscure. Much effect has been attributed to the influence of sudden changes of temperature; to the rapid supervention of an exceedingly moist and comparatively cold air on a hot season, whereby the profuse action of the skin is suddenly checked; and to the influence of malaria. But the extraordinary disproportion of cases of abscess in different parts of the world seems to negative all these surmises.

One fact seems to come out clearly from Dr. Waring's observations, viz., that recent arrival in India is favorable to the occurrence of abscess, and that (all kinds of abscesses being put together) 50 per cent. occur in men under three years' service. No length of residence, however, confers perfect immunity. It would be very important to determine whether the effect of recent arrival is marked, both in cases of abscess consecutive, and in those anterior, to dysentery.

It is possible, also, that some entozoic influence may be at work, espe-

[1] Indian Annals, 1855. Dr. Macnamara found a most extraordinary amount of fatty degeneration of the liver.

[2] Health of European Troops in India, Indian Annals, 1858, p. 109. It is particularly recommended that this chapter should be carefully perused.

[3] It is, however, remarkable how many cases of dysentery occur without producing hepatic abscess; still our general knowledge of the causation of disease makes it highly probable that dysentery acts in this way. Is it the sloughing dysentery which is followed by hepatic abscess?

cially in some parts of India, and hydatid disease of the liver or other diseases of the same class may be more common than is supposed.

In the absence of perfect knowledge, great care in preserving from chills, and proper diet, are the only preventive measures which can be suggested for primary hepatic abscess.

Insolation.

Under this convenient term, a number of cases are put together which seem to be produced by one or more of the following causes:—

External Causes.—1. Direct rays of the sun on the head and spine. Adopt light coverings, covered with white cotton; permit a good current of air between the head and the covering, and use a light muslin or cotton rag, dipped in water, over the head under the cap. 2. Heat in the shade, combined especially with stagnant and impure air. In houses (and men have been attacked with insolation both in tents and barracks) means can always be taken to move the air, and thus keep it pure, even if it cannot be cooled. In tents the heat is often exceedingly great, simply from the fact that there is not sufficient movement of air; in the tropics a simple awning is much better than tents, and if the awning is sloped a little, the top of the slope being toward the north, the movement of air will be more rapid than if the canvas be quite flat. But in the dry season, in the tropics, the men should sleep in the open air in all non-malarious districts, when they are on the march or in campaigns.

The general prophylaxis has been thus summed up by Professor Maclean:[1]—"Men will bear a high temperature in the open air with comparative impunity, provided (*a*) it is not too long continued; (*b*) that the dress be reasonably adapted to the temperature; (*c*) that the free movement of the chest be not interfered with."

Internal Causes.—It is only known that spirit drinking, even in moderation, powerfully aids the external causes of insolation; even wine and beer probably have this effect. Tea and coffee, on the other hand, probably lessen the susceptibility.

A full habit of body, or any tendency to fatty heart or emphysematous lungs, have been supposed also to predispose.

It seems certain that any embarrassment of the pulmonary circulation aids the action of the heat, and therefore the most perfect freedom from belts and tight clothes over the chest and neck is essential.

Great exhaustion from fatigue aids the action, either from failure of the heart's action or want of water. In this case diffusible stimuli, such as ammonia, tincture of red lavender, tincture of cardamoms, etc., with strong coffee are the best preventives. Spirits should not be given, unless the exhaustion be extreme, and the diffusible stimuli cannot be obtained. A small quantity in hot water may then be tried.

Cold baths, and especially cold douching to the head and spine, are most useful as preventive as well as curative measures.

Phthisis Pulmonalis.

In respect of causes, we must distinguish those usually rapid cases of tuberculosis which arise from hereditary constitutional causes, or from the influence of exanthemata (especially measles), or of typhoid, or other fevers, and which run their course with implication of several organs at an early

[1] Reynolds' System of Medicine, vol. ii., p. 157.

stage, and the more chronic forms of phthisis, in which the lung in adults is the first seat of the disease, and other organs are secondarily affected. Several distinct diseases are confounded under the one term of phthisis, and it is therefore not possible at present to trace out their precise origin.

Taking only the common cases of subacute or chronic phthisis, it has been already intimated that most European armies have been found to furnish an undue proportion of such cases.[1]

A few years ago much influence was ascribed to food as a cause of phthisis; the occurrence of a sort of dyspepsia as a forerunner (though this does not seem very common), and the great effect of the treatment by diet (by cod-liver oil), seemed to show that the fault lay in some peculiar malnutrition, which affected the blood, and through this the lungs.

Probably there is truth in this; but of late years the effects of conditions which influence immediately the pulmonary circulation and the lungs themselves have attracted much attention. The effect of want of exercise (no doubt a highly complex cause, acting on both digestion and circulation), and of impure air, have been found to be very potent agencies in causing phthisis, and conversely, the conditions of prevention and treatment which have seemed most useful are nutritious food and proportionate great exercise in the free and open air. So important has the last condition proved to be, that it would appear that even considerable exposure to weather is better than keeping phthisical patients in close rooms, provided there be no bronchitis or tendency to pneumonia or pleurisy.

Three points, then, are within our control as regards phthisis—arrangement of food, exercise, and pure air.

That food should contain a good deal of the nitrogenous and fatty principles if phthisis is apprehended. Milk has been long celebrated, and lately the koumiss of Tartary has obtained a great reputation in Russia as an agent of cure, and is now a good deal used (made from cow's milk) in this country.

Exercise is of the greatest importance, and it would seem quite clear that this must be in the open air. The best climates for phthisis are perhaps not necessarily the equable ones, but those which permit the greatest number of hours to be passed out of the house.

In the house itself, attention to thorough ventilation, *i.e.*, to constant, though imperceptible movement of the air, is the point to be attended to.

In the case of soldiers, it must also be seen that no weights or straps impede the circulation of blood through the lungs and heart.

The effect of a wet subsoil in the causation of phthisis must not be overlooked. Whatever may be the exact amount of truth, we are bound to act as if it were certain.

That the syphilitic disease of the lungs has sometimes a completely phthisical character is tolerably clear, but syphilis will not account for the amount of phthisis in the army. The influence of masturbation in producing phthisis is uncertain.

The researches of Koch, and the discovery of a supposed phthisis *bacillus*, have revived the notion of the communicability of the disease, an idea long held by Italian physicians. This would only be a still greater argument for the freest ventilation indoors, and for a large part of the

[1] There are two valuable pieces of evidence of phthisical and scrofulous disease being developed in a healthy population from impure air, viz., Mr. Morgan's essay on "Phthisis on the West Coast of Scotland" (Brit. and For. Med.-Chir. Rev.), and the analogous case of Western Canada, given by Mr. Mackeleave (Medical Times and Gazette, August, 1868).

patient's time being spent out of doors. It would also indicate the inadvisability of allowing healthy individuals (especially children) to sleep with or occupy the same sleeping-rooms as phthisical persons. It would also be an argument against massing phthisical persons together, although there does not seem to be any direct evidence of injury arising from consumption hospitals, which are, however, always freely and carefully ventilated.

Scurvy.

The peculiar state of malnutrition we call scurvy is now known not to be the consequence of general starvation, though it is doubtless greatly aided by this. Men have been fed with an amount of nitrogenous and fatty food sufficient not only to keep them in condition, but to cause them to gain weight, and yet have got scurvy. The starches also have been given in quite sufficient amount without preventing it. It seems, indeed, clear that it is to the absence of some of the constituents of the fourth dietetic group, the salts, that we must look for the cause.[1]

Facts seem to show with certainty that in the diet which gives scurvy there is no deficiency of soda or of iron, lime, or magnesia, or of chloride of sodium. Nor is the evidence that salts of potash or phosphoric acid are deficient at all satisfactory. And when we think of the quantity of phosphoric acid which must have been supplied in many diets of meat, and cerealia, which yet did not prevent scurvy, it seems very unlikely that the absence of the phosphates can have anything to do with it.[2]

The same may be said of sulphur. Considering the quantity of meat and of leguminosæ which some scorbutic patients have taken, it is almost impossible that deficiency in sulphur should have been the cause.

By exclusion, we are led to the opinion that if the cause of scurvy is to be found in deficiency of salts, it must be in the salts whose acids form carbonates in the system. For, if we are right in looking to a deficiency in the fourth class of alimentary principles as the cause of scurvy, and if neither the absence of soda, potash, lime, magnesia, iron, sulphur, or phosphoric acid can be the cause, then the only mineral ingredients which remain are the combinations of alkalies with those acids which form carbonates in the system, viz., lactic, citric, acetic, tartaric, and malic. That these acids are most important nutritional agents no one can doubt. The salts containing them are at first neutral, afterward alkaline, from their conversion into carbonates; they thus play a double part, and moreover, when free, and in the presence of albumen and chloride of sodium, these acids have peculiar powers of precipitating albumen, or perhaps of setting free hydrochloric acid. Whatever may be their precise action, their value and necessity cannot be doubted. Without them, in fact, one sees no reason why there should not be a continual excess of acid in the system,

[1] For a good deal of evidence up to 1848, reference may be made to a review on Scurvy, contributed by Dr. Parkes to the British and Foreign Medico-Chirurgical Review in that year. The evidence since that period has added little to our knowledge, except to show that the preservative and curative powers of fresh meat in large quantities, and especially raw meat (Kane's Arctic Expedition), will not only prevent, but will cure scurvy. Kane found the raw meat of the walrus a certain cure. For the most recent evidence and much valuable information, see the Report of the Admiralty Committee on the Scurvy which occurred in the Arctic Expedition of 1875–76 (Blue Book, 1877).

[2] Professor Galloway of Dublin, and Mr. Anderson of Coventry, have lately written pamphlets urging the claims of potash and phosphoric acid to attention, but without bringing any fresh evidence of sufficient importance to support their views.

as during nutrition a continual excess of acids (phosphoric, sulphuric, uric, hippuric) is produced, sufficient, even when the salts with decomposable acid are supplied, to render all excretions (urinary, cutaneous, intestinal) acid. The only mode of supplying alkali to the acids formed in the body is by the action of the phosphates, which is limited. The only manufacture of alkali in the body is the formation of ammonia, so that these salts are most important as antacids. Yet it is not solely the absence of alkali which produces scurvy, else the disease would be prevented or cured by supply of pure or carbonated alkalies, which is not the case.

When, in pursuing the argument, we then inquire whether there is any proof of the deficiency of these particular acids and salts from the diets which cause scurvy, we find the strongest evidence not only that this is the case, but that their addition to the diet cures scurvy with great certainty.[1] They will not, of course, cure coincident starvation arising from deficiency of food generally, or the low intercurrent inflammations which occur in scurvy, or the occasionally attendant purpura, but the true scorbutic condition is cured with certainty.

Of the five acids, it would appear unlikely that the lactic should be the most efficacious. If so, how is it that in starch food, during the digestion of which lactic acid is probably formed in large quantities, scurvy should occur? Is, in such a case, an alkali necessary to insure the change of the acid into a carbonate?

Vinegar is an old remedy for scurvy, and acetic acid is known to be both a preventive of (to some extent) and a cure for scurvy. But it has always been considered much inferior to both citric and tartaric acids. Possibly, as in the case of lactic acid, an alkali should be supplied at the same time, so as to enable the acid to be more rapidly transformed.

Tartaric and (especially) citric acids, when combined with alkalies, have always been considered to be the antiscorbutic remedies, *par excellence*, and the evidence on this point seems very complete.[2]

Of malic acid little is known as an antiscorbutic agent, but it is well worthy of extended trials.

Deficiency of fresh vegetables implies deficiency in the salts of these

[1] This was most clearly shown in the last Arctic Expedition (1875–76). The rations on board ship during winter were ample, containing dried potatoes and other vegetables, preserved vegetables, pickles, bottled fruits, vinegar, and a daily ration of lime juice, besides raisins and currants. In the sledge expeditions all these were cut off except two ounces of preserved potatoes, an inadequate ration under any circumstances. The meat was pemmican and bacon, and there was, of course, no fresh bread. The result was, that this imperfect diet, conjoined with most laborious work, produced a severe outbreak of scurvy, which nearly proved fatal to the whole party. The rapidity with which the sick recovered, on being supplied with lime juice and more favorable diet, was noticeable (see Report, op. cit.).

[2] It is based on a very wide experience, and should not be set aside by the statements of men who have seen only three or four cases of scurvy, often complicated, which happen not to have been benefited by lemon juice. The process of preventive medicine is checked by assertions drawn from a very limited experience, yet made with great confidence. We must remember that many cases of scurvy are complicated —that the true scorbutic condition, inanition, and low inflammation of various organs, lungs, spleen, liver, and muscles, may be all present at the same time. See paper by Dr. Ralfe, of the Seamen's Hospital (1877, reprinted from the Lancet). The Merchant Shipping Act of 1867 was soon followed by a great decrease of scurvy in our mercantile marine; but since 1873 there has been a steady increase, which has been attributed by Mr. Thomas Gray (see Official Memorandum on Sea Scurvy and Food Scales, 1882) to want of more varied food scales. It may, however, have resulted from neglect of lime juice, or the use of a damaged article (see British Medical Journal, September, 1882).

acids, and scurvy ensues with certainty on their disuse. Its occurrence is, however, greatly aided by accessory causes, especially deficiency in food generally, by cold and wet, and mental and moral depression.

The preventive measures of scurvy are, then, the supply of the salts of citric, tartaric, acetic, lactic, and malic acids, and of the acids themselves, and perhaps in the order here given, and by the avoidance, if it can be done, of the other occasional causes.

Experience seems to show that the supply of these acids in the juices of the fresh succulent vegetables and fruits, especially the potato, the cabbage, orange, lime, and grape, is the best form. But fresh fruits, tubers, roots, and leaves are better than seeds. The leguminosæ, and many other vegetables, are useless.

Fresh, and especially raw meat is also useful, and this is conjectured to be from its amount of lactic acid; but this is uncertain.

The dried vegetables are also antiscorbutic, but far less so than the fresh; and the experience of the American war was not so favorable to them as might have been anticipated. Do the citric and other acids in the dried vegetables decompose by heat or by keeping? It would be very desirable to have this question settled by a good chemist. We know that the citric acid in lemon juice gradually decomposes. It does not follow that it should be quite stable in the dried vegetables.

The measures to be adopted in time of war, or in prolonged sojourn on board ship, or at stations where fresh vegetable are scarce, are—

1. The supply of fresh vegetables and fruits by all the means in our power. Even unripe fruits are better than none, and we must risk a little diarrhœa for the sake of their antiscorbutic properties. In time of war *every* vegetable should be used which it is safe to use, and, when made into soups, almost all are tolerably pleasant to eat.

2. The supply of the dried vegetables,[1] especially potato, cabbage, and cauliflowers; turnips, parsnips, etc., are perhaps less useful; dried peas and beans are useless. As a matter of precaution, these dried vegetables should be issued early in a campaign, but should never supersede the fresh vegetables.

3. Good lemon juice should be issued daily (1 oz.), and it should be seen that the men take it.

4. Vinegar (½ oz. to 1 oz. daily) should be issued with the rations, and used in the cooking.

5. Citrates, tartrates, lactates, and malates of potash should be issued in bulk, and used as drinks, or added to the food. Potash should be selected as the base, as there is seldom any chance of the supply of soda being lessened. The easiest mode of issuing these salts would be to have packets containing enough for one mess of twelve men, and to instruct the men how important it is to place them in the soups or stews. Possibly they might be mixed with the salt, and issued merely as salt. Lozenges made of citric acid or desiccated lime juice and sugar are well worth a trial.

[1] Probably dried fruits, such as raisins and currants (which contain some acid and vegetable salts) are useful as antiscorbutics. The American pemmican contains them, and men are said to live upon it for months together without suffering from scurvy. It appears to have been that kind of pemmican on which the crew of the "Polaris" lived, who drifted on an iceberg for six months. Other dried fruits, such as apples, would probably also be efficacious.

Military Ophthalmia.

The term "military ophthalmia" is often applied particularly to that disease in which the peculiar gray granulations form on the palpebral conjunctiva. But any severe form of purulent ophthalmia spreading in a regiment is often classed under the same heading. Diseases of the eyes are a source of very considerable inefficiency in the army, and even a casual visitor to the Royal Victoria Hospital must be struck by the large number of men he will meet with who have some affection of the eyes. A reference to the "Army Medical Reports" will also show what great attention is being paid to this important subject by military surgeons, especially by Professor Longmore.[1]

Epidemics of military ophthalmia (gray or vesicular granulations, and rapid purulent ophthalmia), seem to have been uncommon, or perhaps unknown, on the large scale in the wars of the eighteenth century.

The disease, as we now see it, is one of the legacies which Napoleon left to the world. His system of making war with little intermission, rapid movements, abandonment of the good old custom of winter quarters, and intermixture of regiments from several nations, seem to have given a great spread to the disease; and though the subsequent years of peace have greatly lessened it, it has prevailed more or less ever since in the French, Prussia, Austrian, Bavarian, Hanoverian, Italian, Spanish, Belgian, Swedish, and Russian armies, as well as in our own. It has also been evidently propagated among the civil population by the armies, and is one more heritage with which glorious war has cursed the nations. Our last Egyptian campaign (1882), which was very short, does not appear to have produced much ophthalmia among the troops engaged.

In some cases, as in the Danish army, it has been absent till manifestly introduced (in 1851); in other instances it has been supposed to originate spontaneously from overcrowding and foul barrack atmosphere, and from defective arrangements for ablution.[2] Here, as in so many other cases, we find that the question of origin *de novo*, however important, need not be mixed up with that of the necessary preventive measures. What is important for us is to know—*first*, that it is contagious, that is, transmissible; and, *secondly*, that if not produced, its transmissibility is singularly aided by bad barrack accommodation.

The measures to be adopted if military ophthalmia prevails—

1. *Good Ventilation and Purity of the Air.*—In the Hanoverian army, Stromeyer reduced the number of cases in an extraordinary degree, simply by good ventilation. The only explanation of this must be that the dried particles of pus and epithelium, instead of accumulating in the room, were carried away, and did not lodge on the eyelids of the healthy men. The evolution of ammonia from decomposing urine has also been assigned as a cause, and this would be also lessened by good ventilation.

[1] Ophthalmoscopes are now issued to the different stations, and an Ophthalmoscopic Manual has been drawn up by Mr. Longmore for the use of army medical officers. As giving a good survey of military ophthalmia in the British army, the excellent papers of Dr. Frank (Army Medical Report for 1860) and Dr. Marston (Beale's Archives) should be also referred to. A very interesting paper has also been published by Mr. Welch (A.M.D., formerly 22d Regiment), (Army Medical Report, vol. v., p. 494, 1865), on the "Causes aiding the Development of Granulations at Malta." A warm, moist, impure atmosphere is shown to have a great influence.

[2] See Frank's papers (Army Medical Report for 1860, p. 406) for some remarks on its spontaneous origin.

It would appear likely that bad barrack air predisposes to granular conjunctivitis by producing some peculiar state of the palpebral conjunctiva and glands (Stromeyer and Frank), and if a diseased person then introduces the specific disease, it spreads with great rapidity, or possibly, as Mr. Welch's facts seem to show, the impure atmosphere is the great cause, and contagion only secondary.

2. *Careful Ablution Arrangements.*—An insufficient quantity of water for cleansing basins, and the use of the same towels, are great means of spreading the disease, if it has been introduced. Whenever men use the same basins, they should be taught to thoroughly cleanse them; and it would be well if, in every military ablution room, the men were taught not only to allow the dirty water to run away, but to refill the basin with water, which the next comer would let off before filling with fresh water for himself. If some mechanism could be devised for this, it would be very useful. The same towel is a most common cause of propagation; or a diseased man using always the same towel may reinoculate himself. The towels should be very frequently washed (probably every day), and should be dried in the open air, never in the ablution room or barrack.

In some cases special ablution arrangements may cause a good deal of granular conjunctivitis. In 1842 and 1843 Dr. Parkes witnessed, in a regiment newly landed in India from England, a very great number of cases of this kind. The supply of water was very insufficient; many men used the same basins, which were very imperfectly cleaned; the same basins were used for washing and also for dyeing clothes; at that time the men in the cold months wore trousers of a black drill, and when the dye came off they were accustomed to rudely replace it; they themselves ascribed the very prevalent ophthalmia to the irritating effect of the particles of the dye left in the basins and getting into the eyes. There were enormous granulations on both upper and lower lids, and the disease was believed to be communicable, but whether the affection was strictly to be classed with the vesicular granulations is not known.

3. In some cases the use of the bedding (pillows and pillow-cases), which has been used by men with gray granulations, has given the disease to others, and this has especially occurred on board transports. In time of war especially this should be looked to. If any cases of ophthalmia have occurred on board ship, all the pillows and mattresses should be washed, fumigated, and thoroughly aired and beaten. The transference has been in this case direct, particles of pus, etc., adhering to the pillow and mattresses, and then getting into the eyes of the next comers.

4. Immediately the disease presents itself, the men should be completely isolated and allowed to have no communication with their comrades. It has been a great question whether a Government is justified in sending soldiers home to their friends, as the disease has been thus carried into previously healthy villages. It would seem clear that the State should bear its own burdens and provide means of isolation and perfect cure, and not throw the risk on the friends and neighbors of the soldier.

An important matter to remember in connection with gray granulations is that relapses are very frequent; a man once affected has no safety (Warlomont); simple causes of catarrh and inflammation may then reinduce the specific gray granulations with their contagious characters; so that a man who has once had the disease is a source of danger, and should be watched.

Venereal Diseases in the Army.

It is convenient for our purpose to put together all diseases arising from impure sexual intercourse, whether it be a simple excoriation which has been inoculated with the natural vaginal mucus or with leucorrhœal discharges, and which may produce some inguinal swelling, and may either get well in a few days or last for several days; or whether it be an inflammation of the urethra produced by specific (or non-specific? leucorrhœal?) discharge; or whether it be one of the forms of syphilis now diagnosed as being in all probability separate and special diseases, having particular courses and terminations.

In the army men enter the hospital from all these causes, and from the remoter effects of gonorrhœa or syphilis, orchitis, gleet, stricture, bladder and kidney affection; or syphilitic diseases of the skin, bones, eyes, and internal organs.

The gross amount of inefficiency in the army is tolerably well known, but it will require a few more years before the several items of the gross amount are properly made out. This arises partly from an occasional great difficulty in the diagnosis of true infecting syphilis, and partly from a want of uniformity in nomenclature.

The comparative amount of army and civil venereal diseases is not known, because we have no statistics of the civil amount. It is no doubt great. It is a question whether a large majority of the young men of the upper and middle classes do not suffer in youth from some form of venereal disease. In the lower classes it is perhaps equally common.

The sequences are most serious; neglected gleet, stricture, secondary and tertiary syphilis, are sad prices to pay for an unlawful (in some cases a momentary) gratification; and in the army the State yearly suffers a large pecuniary loss from inefficiency and early invaliding. In campaigns the inefficiency from this cause has sometimes been great enough to alarm the generals in command and to increase considerably the labor and sufferings of the men who are not affected.

The preventive measures against venereal diseases are—

1. *Continence.*—The sexual passion in most men is very strong—strong enough, indeed, to lead men to defy all dangers and to risk all consequences. It has been supposed by some that, in early manhood, continence is impossible, or, if practised, is so at the risk of other habits being formed which are more hurtful than sexual intercourse, with all its dangers. But this is surely an exaggeration; the development of this passion can be accelerated or delayed, excited or lowered, by various measures, and continence becomes not only possible, but easy.

For delaying the advent of sexual puberty and desire two plans can be suggested—absence from exciting thoughts and temptation, and the systematic employment of muscular and mental exercise. The minds of the young are often but too soon awakened to such matters, and obscene companions or books have lighted up in many a youthful breast that *feu-d'enfer* which is more dangerous to many a man than the sharpest fire of the battle-field would be. Among young soldiers this is especially the case; while, in spite of the exciting literature of the day, and of the looseness of some of the older boys at the public schools or at the universities, the moral tone of the young gentlemen of our day is better than it was some half century ago, the conversation of the classes from which the soldier is drawn is still coarse and lewd as in the middle ages. There is too close a mixture of

the sexes in the English cottages for much decency, and the young recruit does not often require the tone of the barrack to destroy his modesty. In fact, it is possible that, in good regiments, he will find a higher moral tone than in the factory or the harvest-field.

We must trust to a higher cultivation and moral training to introduce among the male youth of this nation, in all its grades, a purer moral tone. In the army, the example of the officers and their exertions in this way would do great things if we could hope that the high moral tone which happily exists in some cases could inspire all.

It is not the less necessary to save the young from direct temptation. The youth of this nation are now solely tempted, for in our streets prostitation is at every corner. Whatever may be the objection to police regulations, we have surely a right to demand that the present system of temptation shall be altered. It may not be easy to exclude all prostitutes, especially of the better class (whose calling is less easily brought home to them), from public thoroughfares, but, practically, open prostitution can be recognized and made to disappear from our streets. It has been said our police regulations are sufficient for this; they have never yet proved so; and in no European country but England is prostitution so open and so undisguised.[1]

In the Acts passed in 1864,[2] 1866, and 1869, and in the Licensing Act of 1872 (Acts of the greatest importance as the first steps in an efficient legislation), authority has been now taken to prevent prostitutes from assembling in the public-houses, and to a certain extent sources of temptation have been removed.

If young men can thus escape an appeal to their passions, continence is much more easy. There are times when the strictest virtue may well dread such an appeal. Human nature is but too weak, and needs every safeguard it can get.

As aids to continence, great physical and mental exertion are most powerful. It would seem that, during great exercise, the nervous energy is expended in that way, and erotic thoughts and propensities are less prominent; so also with mental exercise, in perhaps a less degree. The establishment of athletic sports, gymnasia, and comfortable reading-rooms in the army, may be expected to have some influence.

Temperance is a great aid to continence. In the army the intemperate men give the greatest number of cases of syphilis; and when a man gets an attack, it is not infrequently found that he was drunk at the time.

The measures which promote continence are, then—

(*a*) The cultivation of pure thought and conversation among the young soldiers, by every means in our power.

(*b*) Removing temptation.

(*c*) Constant and agreeable employment, bodily and mentally; as idleness is one great cause of debauchery.

(*d*) Temperance.

[1] The effect of this upon the virtuous female population is very serious. Every servant in London sees the fine clothes and hears of the idle luxurious lives of the women of the town, and knows that occasionally respectable marriage ends a life of vice. What a temptation to abandon the hard work and the drudgery of service for such a career, of which she sees only the bright side! It is a temptation from which the State should save her. She should see prostitution as a degraded calling only, with its restrictions and its inconveniences.

[2] An Act for the Prevention of Contagious Diseases at Certain Naval and Military Stations, 1864; an Act for the Better Prevention, etc., 1866 (cited as Contagious Diseases Act, 1866).

2. *Marriage.*—It is very doubtful whether those who condemn early marriages among the working-classes, on account of improvidence, are entirely right in their argument. The moral effect of prolonged celibacy has seldom been considered by them. Probably the early marriages are the salvation of the working youth of this country; and in the present condition of the labor market, the best thing a working-man can do is, as early as possible, to make his home, and to secure himself both from the temptations and expenses of bachelorhood. In the case of the soldier the conditions were formerly different for different men; the private soldier who had enlisted for long service (twelve years, and prospect of renewal) could not marry for seven years, and then only 7 per cent. could marry with leave. It was difficult to avoid this, and the consequences were certainly most serious. Under the new system of seven years' enlistment, and passage into the reserve, a soldier will not marry at all, and it is of course desirable he should not do so. If he enlists at nineteen, at twenty-six he will be free; and if kept in full occupation, and as far as possible shielded from temptation, the burden of celibacy will not weigh upon him. Continence would be desirable for his health and for the welfare of his future offspring. The short service now introduced may indeed greatly influence this matter, and certainly has removed from pressing discussion the question of marriage in the infantry of the army.

3. *Precautions against the Disease.*—Admitting that, in the case of a body of unmarried men, a certain amount of prostitution will go on, something may be done to prevent disease by extreme cleanliness, instant ablution, and by the use of zinc, alum, and iron washes, or similar lotions, after connection, and by the constant use by prostitutes of similiar washes. It may seem an offence against morality to speak of such things; but we must deal with things as they are, and our object now is not to enforce morality, but to prevent disease. The use in brothels of these measures appears to be more efficacious than any other plan. In some of the French towns the use of lotions and washings is rigorously enforced, with the effect of lessening disease considerably.

4. *Detection and Cure of Diseased Men and Women.*—In the case of the soldier who has medical advice at hand, it seems of the greatest importance to have instant medical aid at the first sign of disease. But instead of this the soldier conceals his ailment as long as possible, because he will be sent to hospital, put under stoppages, etc. A late regulation made this even more stringent, but it is now happily rescinded. The soldier should be encouraged to make immediate application, and he should certainly not be punished for a fault which his superiors commit with impunity, and for which the State is in part answerable by enforcing celibacy. Our object is to preserve the man's health and services for the State; we shall not accomplish this by ignoring what is a common consequence of his conditions of service.

It has been proposed to detect and cure the disease in prostitutes. A great outcry has been raised against this prososal, which is yet a matter of precaution which the State is surely bound to take. A woman chooses to follow a dangerous trade—as dangerous as if she stood at the corner of a street exploding gunpowder. By practising this trade she ought at once to bring herself under the law, and the State must take what precautions it can to prevent her doing mischief. The State cannot prevent prostitution. We shall see no return to the stern old Scandinavian law which punished the prostitute with stripes and death; but it is no more interference with the liberty of the subject to prevent a woman from

propagating syphilis than it would be to prevent her propagating small-pox.

The difficulty is to detect when she is diseased. Abroad, an elaborate system is in use for this purpose; brothels are registered and their inmates regularly examined. In this country such a system seems to many people too like a recognition of the inevitableness of prostitution, and to a certain extent a sanction of it; it is really, however, a simple matter of precaution. A custom exists which we cannot set aside; let us obviate its effects as best we may, while, at the same time, by higher culture and other efforts, we endeavor to gradually remove the custom.[1]

A partial adoption of this plan has been commenced by the military and naval authorities in this country, and Acts have been passed (1864, 1866, and 1869) by means of which the prostitutes of certain military and naval stations are brought under supervision.[2] The important clause in the Act for 1866 is clause 15, which provides that when an information is made on oath that a woman is a common prostitute, living within the limits of any place to which the Act applies, or having been within those limits for the purpose of prostitution, a justice may issue notice to such woman, through the superintendent of police, to appear for medical examination. She is then kept under continued inspection, and certified Lock hospitals are provided for her treatment if she is discovered to be ill. Clause 36 is also an important one; it imposes a penalty of £20, or imprisonment, with or without hard labor, on any brothel-keeper or owner of a house who, having reasonable cause to know a woman to be a prostitute, and to be affected with a contagious disease, allows her to resort to the house for the purpose of prostitution.

This Act came into force on October 1, 1866; and in some stations, as at Aldershot, it was really more than half a year after this time before it could be put into force.

Since the passing of these Acts there has been a most decided decrease in the number of primary venereal sores at all the military stations under the Acts, compared with non-protected stations. And this is the more satisfactory because the frequent movement of the troops, and the number of stations where there is no control of disease, render the working of the Acts difficult.[3]

[1] Those persons who shut their eyes to the enormous prostitution of this country, as of all others, or think nothing can be done because it is impossible to deal with private or "sly" prostitution, and with the higher grades of the calling, should remember that some movement in the interest of the unhappy girls themselves is necessary. In the low brothels in London the system is a most cruel one. A girl is at first well treated, and encouraged to fall into debt to her employer. As soon as she is fairly involved she is a slave; there is no relief till she can make no more money, when she is cast out. Surely something should be done to save her. Possibly it might be well to try the plan of recognizing no debts from a girl to the procuress or brothel-keeper, and to also devise means for at once giving her the means of release from her life if she desires it. Also, if such houses must exist—and who can venture to hope they will not?—they may at least be made less indecent, quieter, and safer from theft, and even murder. At present, the system, as it exists, is a gigantic scandal to Christianity, and Jeannel's singular work has lately shown how curious a parallel there is between modern prostitution and that which dimmed the splendor, and perhaps hastened the fall, of Imperial and Pagan Rome. Eighteen centuries after the death of Christ, are we still at such a point?

[2] The military stations named in the Contagious Diseases Act in 1866 are Portsmouth, Plymouth, and Devonport; Woolwich, Chatham, and Sheerness; Aldershot, Windsor, Colchester, Shorncliffe, Curragh, Cork, and Queenstown. Others have since been added. Adjoining parishes are in many cases included.

[3] For the statistics of this question, see Army Medical Report for 1880, vol. xxii., pp. 12–17 and 368–371.

But the following figures, from the "A. M. D. Report" for 1880, are quite convincing.

In 1880 there were fourteen stations under the Contagious Diseases Act, with a mean strength of 44,026 men; putting against these all other stations not under the Act, with an average strength of 39,869 men, we have the following ratio:—

Admission per 1,000 *of Strength.*

	Primary. Venereal Sore.	Gonorrhœa.
Fourteen stations under the Act 1880.....	74	100
All other stations not under the Act 1880.....	119	114

It must be remembered that at present gonorrhœa has not been touched by the Act, for want of hospital accommodation, so that the nearly equal amount of gonorrhœa of the two classes shows that the enormous lessening of primary venereal sore in the controlled stations is owing to a real diminution of syphilis, and not to lessened frequency of intercourse. This is proved again by the following figures given by Dr. Balfour.

In 1864, the year before the Act came into operation, the average admissions at all the stations from primary venereal sore were 108.6 per 1,000. In 1872, at the uncontrolled stations, the number was still higher, being 123.2, so that syphilis had not declined in the uncontrolled stations. But in the controlled stations in 1872 the admissions were only 53.3. Therefore, the gain to the State in the controlled stations was (108.9–53.3) 55 admissions less per 1,000 of strength; and in a mean strength of 50,000 men the State was saved the cost of 2,750 cases of primary venereal sore in that year, and the men were saved the enormous injury to their health which would otherwise have resulted.

Let the facts be put in another form. Taking the first seven years that the Acts were in operation (before the introduction of the stoppage regulation in 1873), viz., 1865–72 (though in the early years the operation was partial and imperfect), we have the following figures:

Admission per 1,000 *of Strength,* 1865–72 *inclusive.*

	Primary Sores.	Gonorrhœa
All stations not under the Act (mean strength 32,528 men).....	103.1	111.7
Stations under the Act (mean strength 30,765 men)..	62.8	115.0

There was therefore a practical identity in gonorrhœal admissions, but the annual admissions for primary venereal sores were reduced in the controlled stations by 40.3 per 1,000. In the eight years the State was therefore saved very nearly 10,000 cases of syphilis; and supposing each demanded twenty days of treatment (which is moderate), 200,000 days of sickness have been saved in eight years.

Such, then, has been the operation of the Act under many disadvantages, but this has not been its only beneficial effect.

The Act at the large stations has done great good in some other directions, especially as regards the women. Many women have been reclaimed; the horrible juvenile prostitution has almost ceased, and comparative decency has been taught in the hospitals. Still the act is too feebly drawn, and too partially carried out, to cope entirely with the evil. The prostitutes are not thoroughly under inspection; many are not inspected at all;

neighboring towns send in prostitutes; and hospital accommodation is insufficient.

The prostitutes from surrounding districts not in the Act also come into these towns and camps, either remaining for a few days and then disappearing, or, if diseased, stopping till they can get admitted into hospital. Regiments coming from other quarters not under the Act; men coming from furlough or detachment, also introduce the disease; in fact the means of evasion and of reintroduction are numerous.

One consequence of the Contagious Diseases Act was to make public the most frightful state of things among the women of our garrison towns. The vivid picture of the Chatham prostitute's life, drawn by Mr. Berkeley Hill,[1] was no exaggeration. Reports from the Lock hospitals at other places would, if published, have borne out all Mr. Hill alleged. Shocking as these disclosures are, and mortifying as they may be to our national pride, it is by far the best plan to have them made. An evil like this must not be treated in the shade; it will never be overcome till the public know its proportions; the deadly mists which cling round and poison the very basis of society can be dispersed only when the healing light of the sun falls on them. It is at any rate encouraging to learn that the effect of the Act has been greatly to improve the manners and habits of the women—to impose some restraint on them, and to restore to them something that, in comparison with their former life, may be called decency.

[1] British Medical Journal, 1867.

CHAPTER XIX.

DISINFECTION AND DEODORIZATION.

The term *disinfectant*, which has now come into popular use, has unfortunately been employed in several senses. By some it is applied to every agent which can remove impurity from the air;[1] by others, to any substance which, besides acting as an air purifier, can also modify chemical action, or restrain putrefaction in any substance, the effluvia from which may contaminate the air; while, by a third party, it is used only to designate the substances which can prevent infectious diseases from spreading, by destroying their specific poisons. This last sense is the most correct, and it is that which is solely used here. The term *disinfectant* might also be applied to substances destroying *entozoa* or *ectozoa*, or *epiphytes* or *entophytes*, but there is a disadvantage in giving it so extended a meaning. The mode in which the poisons are destroyed, whether it be by oxidation, deoxidation, or arrest of growth, is a matter of indifference, provided the destruction of the poison is accomplished. The general term *air purifier* is given in this work to those agents which in any way cleanse the air, and which therefore include disinfectants; and the term *sewage deodorants*, to those substances which are used to prevent putrefaction in excreta, or in waste animal or vegetable matters, or to remove the products of putrefaction. In a great many instances the substances which are recommended as *disinfectants* are little more than *deodorants*, and ought properly to be spoken of as such.

The chief human diseases which are supposed to spread by means of special agencies (conveniently designated under the name of "contagia"),[2] are, the exanthemata; typhus exanthematicus; enteric (typhoid) fever; relapsing fever; yellow fever; paroxysmal and the allied remittent fevers; dengue; cholera; bubo-plague; influenza; whooping-cough; diphtheria; erysipelas; dysentery (in some cases); puerperal fever; syphilis; gonorrhœa; glanders; farcy; malignant pustule; and, perhaps, phthisis. There are some few others more uncommon than the above.

It has long been a belief that the spread of the infectious diseases might be prevented by destroying the agencies in some way, and various fumigations, fires, and similar plans have been employed for centuries during great epidemics.

In order to apply *disinfection* in the modern sense of the term, we ought to know—1st, the nature of these contagious agencies; 2d, the media

[1] Tardieu, for example, Dict. d'Hyg., art. "Désinfection," and many other authors.

[2] It will be seen that the old distinctions between *infectious* and *contagious* diseases, and between *miasmata* and *contagia*, are not adhered to. They were at no time thoroughly definite, and are now better abandoned.

through which they spread; and 3d, the effect produced upon them by the chemical methods which are supposed to destroy or modify them.

1. THE NATURE OF THE CONTAGIA.[1]

This point is at present the object of eager inquiry. In the case of one or two of the above diseases, the question has been narrowed to a small compass. In variolous and vaccine discharge, and in glanders, the poison certainly exists in the form of solid particles, which can be seen by high powers as glistening points of extreme minuteness.[2] In cattle plague blood-serum there are also excessively small particles discovered by Beale, which are probably the poison. The size of the particles supposed to be contagia is minute; some of them are not more than $\frac{1}{50000}$th of an inch, and Beale believes that there may be smaller still to be discovered with higher powers. Chauveau has washed the vaccine solid particles in water; the water did not become capable of giving the disease; the washed particles retained their power. The epidermic scales of scarlet fever and the pellicle of the diphtheric membrane certainly contain the respective poisons, and after exposure to the air for weeks, and consequent drying, still retain their potency. It is more likely that solid matters should thus remain unchanged than liquids, but it has not yet been proved that this is so, and at present the exact physical condition of the contagia of the other infectious diseases remains doubtful.

The extraordinary power of increase, and capability of producing their like, possessed by some of the contagia when placed under special fostering circumstances, as in the bodies of susceptible animals, lead to the belief that they are endowed with an independent life. The old doctrines that they are simply either poisonous gases or animal substances in a state of chemical change, and capable of communicating this change, or that, like the so-called ferments (ptyalin, pancreatin, diastase, emulsin), they split up certain bodies they meet, are not now in favor.

The retention of the power of contagion for some time, and its final loss, the destruction of the power by antiseptics which do not affect the action of such bodies as ptyalin or diastase, and the peculiar incubative period which is most easily explained by supposing a gradual development of the active agent in the body, are more in accordance with the hypothesis of independent life and power of growth.

The independent living nature of the contagia is a belief which has long been held in various forms. At the present time there are three views, each of which has some arguments in its favor.

(1) The particles are supposed to be of animal origin, born in, and only growing in the body; they are, in fact, minute portions of bioplasm (to use Dr. Beale's phrase), or protoplasm.[3]

This is the old doctrine of "fomites" expressed in a scientific form, and supported by a fact which was not known until recently. This is that the independent life ascribed to these particles of bioplasm is no assump-

[1] See Report on Hygiene for 1872 (Army Medical Department Report, vol. xiii.).

[2] The observations of Chauveau, Beale, and Burdon-Sanderson, and still more recently, of Braidwood and Vacher, prove this very important point by what seems indisputable evidence. It does not follow that all small bodies are in such fluids the *contagia*, but the experiments prove that some of them must be. In many kinds of blood there are numerous small particles, derived, according to Riess, from retrograde metamorphosis of white blood-cells and which have no contagious property.

[3] This view has been advocated with great force by Beale (Disease Germs, 2d edition); and Morris (The Germ Theory of Disease, 2d edition).

tion, since we are now aware that many of the small animal-cells or bioplastic molecules are virtually independent organisms, having movements, and apparently searching for food, growing, and dying.

This view explains singularly well the fact of the frequent want of power of the contagia of one animal to affect another family; as, for example, the non-transference of many human diseases to brutes, and the reverse. It also partly explains the non-recurrence of the disease in the same animal by supposing an exhaustion of a special limited supply of food, which cannot be restored, since it may be supposed that some particular bodily structure is altogether destroyed, as, for example, Peyer's patches may be in enteric fever. One objection to this view is, on the other hand, that living animal particles die with great rapidity after exit from the body, while the contagia do certainly last for some considerable time.[1]

(2) The particles have been conjectured to be of fungoid nature, and to simply grow in the body after being introduced *ab externo*. This view is supported by the peculiarities of the rapid and enormous growth of *fungi*, by their penetrative powers and splitting-up action on both starchy, fatty, and albuminoid substances, and by the way in which certain diseases of men and animals[2] are undoubtedly caused by them. It is clearly a view which would explain many phenomena of the contagious diseases, and has been supported by the experimental evidence of Hallier and many others, who have believed either that they have invariably identified special *fungi* in some of these diseases, or that they have succeeded in cultivating fungi from particles of contagia. At the present time, however, the evidence of true, recognizable and special *fungi* being thus discovered and grown, and forming the efficient causes, is very much doubted by the best observers. The *micrococci* of Hallier, supposed to be formed by the disintegration of the protoplasm of *fungi*, which Hallier considers can again develop to *fungi*, are looked upon by many as mere detritus.[3]

(3) The particles of contagia are thought to be of the nature of the *Schizomycetes*, *i.e.*, of that class of organisms which Nägeli has separated from the fungi, and which form the lowest stratum at present known to us of the animate world. They are termed *Bacteria*, *Bacilli*, *Microzymes*, *Vibrios*, *Spirilla*, *Monads*, etc. Their relation to the *fungi*, or to the *Oscillarineæ*, to which they are perhaps closer, is yet a matter of warm debate.

That these creatures are concerned in many diseases is clear. Lister's genius first brought their practical importance forward, and the late re-

[1] A modification of this view, under the name of the Glandular Origin of Disease, is advocated by Dr. B. W. Richardson, F.R.S. (Address to the Sanitary Institute of Great Britain, Leamington, 1877; Nature, No. 414, October 4, 1877, p. 480). Admitting that the disease poison generally comes from without, he looks upon its action as catalytic, causing an altered glandular secretion or a change in the blood, the changed secretion reacting on the nervous centre supplying the gland or glands. He also conceives that during epidemic periods a strong nervous impression may have the same effect as the direct introduction of poison from without, so that the disease may occasionally arise spontaneously. He looks upon many diseases as hereditary, in the sense that the condition of the child resembles that of the parent, and will therefore be open to similar influences.

[2] Not only some skin and hair diseases of men and animals, and diseases of insects and fishes, are caused by the growth of fungi which fall on the surface of the body, or are drawn into the mouth, but internal diseases are caused by the growth of undoubted fungi, such as *Aspergillus*.

[3] The supposed fungus, which Klein (Reports of the Medical Officer of the Privy Council, new series, No. vi., 1875) thought he had discovered in the patches of typhoid ulceration, was shown by Creighton to be merely an altered condition of fibrine simulating an independent organism (see Proceedings of the Royal Society, June 15, 1876).

searches of Klebs, Recklinghausen, and others, have shown how great a part they play in the production of Septicæmia. The carbuncular disease of cattle and sheep (splenic apoplexy) is also intimately connected with *Bacilli;* and if the observations of Coze, Feltz, and others are correct, the same is true of typhoid fever. Ferdinand Cohn has asserted,[1] that even the glistening particles of vaccine lymph are *Bacteria*. *Bacteria* have been proved to cause disease of the intestinal mucous membrane, the uterus, the kidneys, and the heart, and they play some part in hemorrhagic small-pox. *Bacilli* were found to be the active agents in the poisoning by ham at Welbeck. Klebs and Tommasi-Crudeli have shown the probability of malarial poisoning being due to a *Bacillus*. Still more recently, Koch has essayed to connect phthisis with a similar organism. The peculiar form of febrile disease observed at Aberdeen by Dr. Beveridge was distinctly connected with the existence of minute organisms in milk.[2] The researches of Pasteur on fowl cholera and charbon have shown not only that those diseases are due to *Bacteria*, but that they can probably be prevented or modified by inoculation with cultivated virus.

Yet in some of the epidemic diseases no *Bacteria* have been as yet demonstrated. In cholera, Lewis and Cunningham have failed, in spite of the most persevering search, to find *Bacteria* (or *fungi*) in the discharges or blood of cholera.

The reasons for attributing in many cases great influence to *Bacteria*, which are undoubtedly present, are obvious enough.

They are so widely spread in nature (in both air and water); their powers of growth, by division, are so wonderful; their food (ammonia, phosphates, and perhaps starches or sugars) is so plentiful, and their tenacity of life so great, that it is no wonder great consequence is now attached to them. Yet it is their very universality which is the strongest argument against the view that they constitute the contagia of any of the specific diseases, and any one who considers the peculiar spread of the contagious diseases will admit the force of this objection. To meet this objection it has been surmised that they are not the contagia, but merely their carriers. This view has not been defined; but as the plasma of *Bacteria* is albuminoid, it may perhaps be taken to mean that while the *Bacteria* are usually harmless, their plasma may become, in certain cases, altered in composition, and then becomes poisonous in different specific ways. *Bacteria* feeding in the blood of a typhus patient will become nourished with morbid plasma, and thus, so to speak, it is diseased *Bacteria* which become dangerous. We get here beyond the range of present observation, and are conscious how impossible it is with our present instruments to investigate such an hypothesis.[3]

The belief which some entertain that *Schizomycetes* are the efficient agents of the contagious diseases has led to a number of experiments on the destruction of *Bacteria* by heat and by chemical agents, in the belief that the doctrine of disinfection was thereby elucidated. This could hardly be

[1] Virchow's Archiv, Band iv., p. 229 (1872).

[2] See note by Professor Ewart, Proceedings of the Royal Society, 1881, vol. xxxii., p. 492.

[3] For further information, see the "Address in Medicine," by W. Roberts, M.D., F.R.S., delivered at the Manchester Meeting of the British Medical Association, 1877 (Brit. Med. Journal, No. 867, August 11, 1877, p. 168). Also Professor Tyndall's papers in the Royal Society's Proceedings and Transactions (see Transactions of the Royal Society, 1876, part i., p. 27); Floating Matter in the Air, by the same author; Nägeli's Niedere Pilze; Fodor's Untersuchungen, op. cit.

the case, unless we are certain that the *Bacteridia* are the contagia, which is not yet proved to be the case. Disinfection must rest at present on its own experimental evidence.

The belief in the part played by *Bacteridia* has led also to much interest being taken in the discussion on ferments, and in the question of spontaneous generation, as it is imagined that a clew might thus be found to the origin, *de novo*, of the contagia. Mr. Darwin's doctrine of Pangenesis has even been pressed into the discussion, though it rather makes the darkness greater than before. It is curious to find so practical a matter as that of disinfection brought into relation with some of the most subtle and controverted questions of the day; but the important bearing which the acceptance of one or other of these views would have on the practice of disinfection is evident.

2. THE MEDIA IN WHICH THE CONTAGIA ARE SPREAD.

Our knowledge of this point is far more defined, and may be thus summarized:—

The special and distinctive phenomena of each disease are usually attended with special implication of some part of the body, and it is especially these parts which contain the contagia. In these parts there is frequently rapid growth, and if the parts are on the surface, frequent detachment. The pus and epidermis of small-pox; the epidermis and the mouth and throat epithelium of scarlet fever; the skin and bronchial secretions of measles; the stools containing the discharged detritus of Peyer's glands in typhoid fever; the discharges of cholera; the discharges and eruptions of syphilis, glanders, farcy, and malignant pustule, are instances of this. In typhus fever the skin is greatly affected, and it is generally supposed that it is from the skin that the virus spreads, since this disorder is so easily carried by clothes; the same is the case with plague. In fact, those parts of the body which are the breeding-places of the contagious particles give off the poison in greatest amount. The portions of the body thus thrown off, and containing the contagia, may then pass into air, or find their way into water or food, and in this way be introduced by breathing, drinking, or eating, or through broken surfaces of the body.

The principles of disinfection ought evidently then to deal with the poisons at their seats of origin, as far as these are accessible to us. It was the instinct of genius which led Dr. William Budd to point out that the way to prevent the spread of scarlet fever is to attack the skin from the very first; to destroy the poison in the epidermis, or failing that, to prevent the breaking up and passage into the air of the particles of the detached epidermic scales. Oily disinfectant inunctions of the skin, and the most complete disinfection of the clothing which touches the skin of the patient, are the two chief means of arresting the spread of scarlet fever. The rules for small-pox are almost identical, though it is more difficult to carry them out. In enteric fever the immediate destruction of all particles of poison in the stools by very strong chemical reagents, and the prevention of the poison getting into sewers or drinking water or food, are the measures obviously demanded by the peculiarities of this special disease.

The more completely these points are investigated, and the more perfectly the breeding-places in the body are known, the more perfect will be our means of disinfection.

3. EFFECTS OF HEAT AS A DISINFECTANT.

If the *contagia* are simply excessively minute portions of bioplastic particles, in Beale's sense, we may be sure they will be easily killed; a heat far below that of boiling water, and very weak chemical agents, destroy all signs of vitality in animal cells and molecules. We might, therefore, hope much from disinfection. *Fungi* in water are destroyed by a comparatively low heat; while in dry air *Penicillium glaucum* is not completely destroyed, according to Pasteur, till 127° C. (= 260° Fahr.), and *Oidium aurantiacum* dies at about the same temperature. On the contrary, the Bacteroid bodies are often extremely stable. Lex found a temperature of 127° C. or 260° Fahr. insufficient to kill them, and after boiling them for half an hour they still showed vital movements; and in Calvert's experiments a heat of no less than 400° Fahr. (= 204° C.) was required to thoroughly destroy them, and some kinds seem unaffected even by strong acids and caustic alkalies. Bastian has, however, stated [1] that *Bacteria* and *Vibrios* are killed at a much lower temperature; his experiments show that a brief exposure to a temperature of 70° C. (= 158° Fahr.) either killed the germs of *Bacteria*, or completely deprived them of their powers of multiplication. Sanderson found that *Bacteria* in water are not developed in fluids heated to 366° Fahr. or even boiled. Disinfection, if *Bacteridia* are to be destroyed, would be then a matter of much greater difficulty. Tyndall [2] has since pointed out what appears to be, at least, a partial explanation of the above discrepancies. He shows, that whilst prolonged boiling failed to sterilize an infusion, successive heatings for a short time, even below the boiling-point, were successful. The explanation proposed is, that during the period of latency the spores are in a hard state capable of resisting high temperature, but that just before the period of active germination, they become softened, and therefore amenable to the influence of heat. As, however, spores in various stages may exist in the same fluid, successive heatings are necessary so as to arrest each group at the proper time; but by repeating the heatings sufficiently often an infusion may be sterilized at a point below the boiling-point of water. Important in all ways, this question of the nature of contagia is especially so in a practical sense, viz., that of the easy or difficult destruction of these agents. It does not, however, follow that ordinary putrefactive *Bacteria* are identical with those which may be supposed to produce disease. It is probable that they are quite different, and that disease *Bacteria* are more easily destructible by heat at least.

Purification of Clothes and Bedding.—The best plan of doing this is certainly by the agency of heat. Dr. Henry, of Manchester, after showing that vaccine matter lost its power if heated to 140° Fahr. for three hours, proposed to disinfect clothing by dry heat. He disinfected scarlet fever clothing by exposure to 212° Fahr. for one hour; woollen clothing from plague patients, after being heated twenty-four hours from 144° to 167° Fahr., was worn with impunity by fifty-six healthy persons for fourteen days. Heat was largely used to disinfect clothing by the Americans in their civil war, both in the form of dry heat and boiling water. It is believed that the cessation of the plague in Egypt, after St. John's day, was due to the increased heat of the air; but possibly the hygrometric condition of the air may have more to do with this. It has also been surmised

[1] Proceedings of Royal Society, No. 143, p. 224, March, 1873.
[2] Ibid., No. 178, p. 569.

that the yellow fever poison is destroyed by an intense heat. Dr. Shaw has collected the few facts which we know on this subject.[1]

Disinfecting Chambers, that is, hot-air chambers, into which clothing, linen, and bedding are put, are used. The usual arrangement is a furnace with the smoke-shaft passing under or on one side of a brick chamber, and with a hot-air blast from a shaft running through or under the fire into the chamber itself, or into a passage below it, whence it passes into the chamber through a valve; an exit for the hot air is provided at the top of the chamber; the clothes are suspended in the chamber, at a little distance from the walls.

In other cases the bottom of the chamber is made of iron, and the smoke-flue passes beneath it; the iron becomes red hot, and is covered with sand, to prevent the clothes taking fire. Hot air is then poured into the chamber in the same way. The disadvantage of the hot-air blast is the uncertainty and variation in the amount of heat.

Fraser has devised a good form of stove, in which high temperature and the use of sulphurous acid are combined. The articles are wheeled into the stove in the cart that brings them. Dr. Ransom, of Nottingham, has devised a gas stove, viz., an iron box well covered with non-conducting material; in a channel leading to it a gas-jet burns; by means of a regulator (modified from Kemp's regulator) the heat is kept uniform day and night; the hourly consumption of gas is 9 cubic feet for a small stove, which is sufficient for the hospital at Nottingham.

Steam has been also used; and, at Berlin, a steam disinfecting chamber proposed by Dr. Esse,[2] is said to work well. This chamber is in the form of two iron cylinders of different diameters, one inside the other, and with walls strong enough to withstand the pressure of the steam; between the two cylinders steam enters from a neighboring boiler, and heats the internal cylinder in which the clothes are suspended; at the top of the cylinder is a brass box which dips a little way down, and is pierced with holes at the bottom, so that the air of the inner cylinder can rise into it; in the box is a thermometer. The outer cylinder is covered with wood, and the top of the cylinder with felt, to economize heat; the steam, when it condenses in space between the cylinders, flows out by means of a valve, which is lifted when the water reaches a certain point in the condenser. The clothes are introduced at the top, the lid of the cylinder being lifted up by a pulley; they are not allowed to touch the cylinder, but are suspended from wooden pegs. In an hour's time the heat can be brought to 90° R. (= 234.5° Fahr.). Another apparatus has been contrived by Esse for mattresses. It is an iron case with a spiral steam pipe in the centre, which heats with compressed steam (two atmospheres).

A steam cylinder has also been used at the London Fever Hospital, for disinfecting the feathers used as bedding.

The ordinary drying closet in a good laundry will sometimes give heat enough, but not always. A baker's oven can also be used on emergency.

The question of temperature has been much discussed. It is desirable to get as high a temperature as possible so as to insure the destruction of disease poison. On the other hand, the temperature must not be too high, for fear of destroying the fabrics.

Ransom found that fine fabrics began to scorch at 255° to 260° Fahr.

[1] Trans. Soc. Science Assoc. for 1864, p. 558.

[2] Deutsche Vierteljahrsch. für off. Gesundheitspflege, Band iii., p. 534 (1871).

In some experiments, undertaken at the request of the Director-General, A.M.D.,[1] the following results were obtained :—*Woollen* fabrics changed color after six hours' exposure at 212° Fahr., or after two hours at 220° Fahr.; generally length of exposure and elevation of temperature were complementary. *Cotton* and *linen* showed signs of change of color after six hours at 212° Fahr., or four hours at 220° Fahr. Professor E. Vallin,[2] of Val de Grâce, found that a piece of new white *flannel* was not more discolored after two hours at 230° Fahr. than after one ordinary washing, and that even after three hours a piece already washed showed no change ; two hours, however, at 240° Fahr. to 250° Fahr. showed distinct change. *Cotton* and *linen* did not change until they had been exposed for two hours to 257° Fahr. The strength of the material was not diminished (as shown by a dynamometer) until after two hours at 300° Fahr. *Horse-hair* became friable after exposure to heat, but this was chiefly an effect of drying, as it regains its ordinary condition after a short time (Vallin, Lake). In Ransom's stove the heat is arranged to be between 235° and 255° Fahr. After an accident at the Southampton Infirmary, where all the clothes, etc., in the chamber were consumed, a modification was introduced by Dr. Ransom ; a chain with a link of fusible metal is set free by the melting of the link as soon as 300° Fahr. are reached ; this closes a door, shuts off the gas, and prevents any further rise of heat. In the Liverpool Chambers 280° Fahr. has been registered, and no less than 380° Fahr. in the drying closet over the Cockle stove.

There is no doubt considerable variation in the temperature of different parts of the chamber, and the effects on fabrics vary according as they are placed on or near the floor and sides, or suspended in the centre or upper parts. At the Southampton Infirmary, all bedding and clothing are exposed in the chamber after every occasion of use, the mean temperature being under 230° Fahr., but there is distinct deterioration of fabric, a loss incurred designedly in order to secure complete destruction of disease poison.

As before stated, we have no reason to believe that disease germs will resist a temperature of 220° Fahr., or even 212° Fahr., if completely and thoroughly exposed to it. Even when liquids, such as water or milk, have been infected, no case of disease has ever been traced to the use of such liquids after being *boiled*. It seems therefore unnecessary to carry the heat to excess, 220° Fahr. being in all likelihood sufficient, or even 212° Fahr. with some length of exposure. In the "Army Medical Regulations" (1878) (655*a*), exposure to a temperature of not less than 212° Fahr. for at least two hours is ordered.

Soaking and Boiling Clothes.—The boiling of clothes is not generally considered so good as baking, but still is very useful. It is desirable to add some chemical agent to the water, and chloride of lime is frequently used in the proportion of 1 gallon of the strong commercial solution to 20 or 30 gallons of water. Carbolic acid (1 part of pure acid and 2 parts of commercial acid to 100 of water) is also much employed. The German military regulations order the clothes to be laid for twenty-four hours in a solution of sulphate of zinc, in the proportion of 1 part to 120, or of chloride of zinc, in the proportion of 1 part to 240, and then to be washed with soap and water, if the clothes cannot be baked. The routine Dr. Parkes

[1] By Dr. F. de Chaumont, Lancet, December 11, 1876.

[2] "De la Désinfection par l'Air chaud," Mémoires de la Société de Médecine Publique et d'Hygiène Professionnelle, 1877.

followed in the case of a large military hospital during war was to receive all dirty clothes into a large open shed, and to plunge them at once into tubs of cold water with chloride of lime. After twelve to twenty-four hours' soaking, according to their condition, they were put into coppers and boiled, chloride of lime being again added to the water; they were then put into the washing-machine, and then dried and baked in a dry closet, heated to the highest point that could be got, about 200° to 230° Fahr. If lice were very numerous, it was a good plan to bake the clothes before soaking; the lice were mostly killed, but some were only torpid, and were still living, after a temperature of probably 200° Fahr. They could, however, be shaken out of the clothes easily even if not dead.

Fumigating Clothes.—This is best done with sulphur, which may be used in the hot chamber, as in Fraser's oven, or the clothes are suspended in a small close chamber or large vat, and a large quantity of sulphur is set on fire, care being taken that the clothes are not burnt. Hair mattresses must be taken to pieces before fumigation if they be much defiled.[1]

4. EFFECTS OF CHEMICAL AGENTS.

Although numerous experiments have been made upon this point, yet our knowledge still remains somewhat obscure. A large number of substances have been proposed, and many actually tried, with varying results. One cause of discrepancy has been the somewhat loose way in which the term *disinfectant* has been employed in cases where the action has been little more than *deodorant*. Chemical agents may be divided into—(*a*) those which actually destroy disease poison and minute organisms; (*b*) those which suspend vitality and propagation; and (*c*) those which merely deodorize, that is, destroy or mask smell. Even such a division cannot be carried out consistently, and all that we can say is, that some substances act powerfully as destroyers of disease poison and minute life, if used in sufficient quantity and degree of concentration; such substances are also generally deodorants. Other substances do not appear positively to destroy disease poison or minute life, but they certainly suspend its vitality for a time, and we may therefore use this interval of suspension advantageously by getting rid of the infected matter without danger in transit.

A further division of chemical agents might be into gaseous, liquid, and solid, and other divisions might also be suggested. Perhaps the most convenient plan will be to state the objects to be attained, and consider the agents which may be used.

Purification of the Air by Chemical Methods.

The great purifying actions of Nature are diffusion, dilution, transference by winds, oxidation, and the fall of rain. In houses the power of ventilation is the only safe method, but some effect can be produced by chemical agencies in aid of ventilation.

The foreign matters in the air which can be removed by chemical means, are carbon dioxide, hydrogen sulphide, ammonia (usually in the form of ammonium sulphide), and various organic substances, arising in an infinity of ways, some being odorous, others not, and of the physical and chemical nature of which little or nothing is known. Air purifiers are also used to check the growth of fungoid, infusorial, or bacteroid organisms. They are used in the form of solids or of liquids, which may absorb the substances

[1] Army Medical Regulations, 1878, part 5, section v., paras. 644–662.

from the air, or of gases which may pass into the air, and there act on the gases or molecular impurities.

(*a*) *Solid Air Purifiers.*—Dried earth, quicklime, charcoal, and calcium and magnesium carbolates (phenates), a mixture of lime and coal-tar, are the most important.

Of these *charcoal* is the most effectual. It presents an immense surface, and has a very extraordinary power of separating and absorbing gases and vapors from the atmosphere,[1] and oxidizes rapidly almost every substance capable of it. Its action is not indiscriminate, but elective (A. Smith); when charcoal which has absorbed oxygen is warmed, it gives off CO_2 (A. Smith), a proof of its great oxidizing power. Exposed to the air in bags or shallow pans, its action is rapid and persistent; its effect is especially marked with sewage gases, and with the organic emanations in disease. It also absorbs hydrogen sulphide. Its power of purifying air from organic emanations is really great, and can be employed in hospital wards with advantage.

Of the different kinds of charcoal, the *animal* charcoal has the highest reputation, and then peat. But the carbon left in the distillation of Boghead coal has been stated to be even better than animal charcoal. If vegetable charcoal be used, it should be rather finely powdered. The disinfecting qualities of charcoal on air scarcely lessen with time if the charcoal be kept dry. Charcoal filters to be placed before the mouth have been recommended by Stenhouse, and might be useful in cases of very impure air. Dried marly earth is much inferior to charcoal, but still can be employed in the absence of the latter.

Quicklime absorbs CO_2 and perhaps compounds of sulphur, and has been employed for that purpose.

Calcium and *magnesium carbolates* have been also used; as they give off carbolic acid, their action is probably chiefly in that way.

(*b*) *Liquid Air Purifiers.*—Solutions of *potassium permanganate* (Condy's red fluid), *zinc chloride*, and *lead nitrate* are sometimes used, being either exposed in flat dishes, or cloths are dipped in the solution and exposed to the air. They act only on the air which comes in contact with them, but in that way absorb a good deal of impurity. Condy's fluid, when well exposed to the air, seems to have a good purifying effect, and to lessen the close smell of ill-ventilated rooms, and it absorbs hydrogen sulphide, and so will also solution of nitrate of lead.

(*c*) *Gaseous Air Purifiers.*—The evolution of gases into the air is the most powerful means of purifying it independent of ventilation. The principal gases are *ozone*, *chlorine*, fumes of *iodine* and *bromine*, *nitrous*, *sulphurous*, and *hydrochloric acid*, *carbolic acid*, *tar fumes*, *acetic acid*, *ammonia*.

Ozone.—It has been proposed to disengage ozone constantly into the air of a room, by heating a platinum wire by a Bunsen cell; by half immersing a stick of phosphorus in tepid water in a wide-mouthed bottle; or by mixing very gradually 3 parts of strong sulphuric acid and 2 parts of permanganate of potassium. This last method is that used by Dr. Fox.[2] The amount of ozone can be measured by the common ozone paper, and the stopper put in if the tint is too deep. It is presumed it will then act as a powerful oxidizing agency, and destroy organic matter, as it certainly removes the putrid effluvia of decomposing blood (Wood and

[1] Sennebier, quoted by Chevallier, Traité des Désinfect., p. 146, and A. Smith.
[2] Ozone and Antozone, p. 25.

Richardson). It was much used by Dr. Moffat in cholera and cattle plague.

Chlorine.—Given off from chloride of lime, moistened with water, or with dilute sulphuric acid, and placed in shallow vessels, or from chloride of soda, or evolved at once. Four parts by weight of strong hydrochloric acid are poured on one part of powdered manganese dioxide, or four parts of common salt and one part of manganese dioxide are mixed with two parts by weight of sulphuric acid and two of water, and heated gently. According to the size of the room, the actual weight of the substances taken must vary. Or two tablespoonfuls of common salt, two teaspoonfuls of red lead, half a wineglassful of sulphuric acid, and a quart of water are taken. Mix the lead and salt with the water, stir well, and add the sulphuric acid gradually. Chlorine is evolved, and is absorbed by the water, from which it is slowly driven out. It may be kept in a jar or stoppered bottle, left open as occasion may require.[1]

Chlorine decomposes hydrogen and ammonium sulphides at once, and more certainly than any other gas. It doubtless destroys organic matter in the air, as it bleaches organic pigments, and destroys odors, either by abstracting hydrogen, or by indirectly oxidizing. Euchlorine, a mixture of chlorous acid and free chlorine, obtained by gently heating (by placing the saucer in warm water) a mixture of strong hydrochloric acid and potassium chlorate, has been also used instead of pure chlorine. It has been strongly recommended by Professor Stone, of Manchester, who has devised a special apparatus for its disengagement. He also uses it by placing fuming hydrochloric acid in a wine-glass, and adding a few grains of chlorate from time to time. In that way there is no danger of explosion, as sometimes is the case if a large quantity of chlorate is warmed with hydrochloric acid. The odor of euchlorine is more pleasant than that of chlorine; it acts as rapidly on iodide of potassium and starch paper, and appears to have a similar action on organic substances; it is probably inferior to pure chlorine, but the ease of development and its pleasanter smell are in its favor.

Iodine can be easily diffused through the atmosphere by placing a small quantity on a hot plate. Dr. Richardson proposes to saturate a solution of peroxide of hydrogen with iodine, and to add 2½ per cent. of sea-salt; by "atomizing" or "pulverizing" the fluid by the little instrument used for this purpose, the air can be charged with iodine and sea-salt spray very readily. Iodine will decompose SH_2, and destroys, therefore, much odor. Its action was investigated by Duroy in 1854,[2] who showed that it is a powerful arrester of putrefaction. As it condenses easily, and does not diffuse everywhere like chlorine, it might be expected to be less useful than chlorine.

Bromine.—In the American civil war bromine was rather largely used as an aërial disinfectant; a solution of bromine in bromide of potassium is placed in saucers and exposed to the air; the vapor is, however, very irritating, and should not be disengaged in too large an amount.

Nitrous Acid or *Nitrogen tetroxide* can be evolved by putting a bit of copper in nitric acid and a little water. The nitrogen dioxide which is given off takes oxygen from the air, and red fumes, consisting chiefly of nitrogen tetroxide or nitrous acid (NO_2), are formed.

The oxidizing action of nitrous acid is very great on organic matter.

[1] Medlock's Record of Pharmacy and Therapeutics, 1858, p. 20.
[2] Chevallier, Traité des Désinfect., p. 19.

It removes the smell of the dead-house sooner than any other gas. It is rather irritating to the lungs, and, in some persons, large quantities of it cause vertigo, nausea, and even vomiting.

The action of nitrous acid results from the ease with which it parts with oxygen to any oxidizable substance, being converted into nitrogen dioxide, which again at once combines with atmospheric oxygen, and so on.

Sulphurous Acid or *Sulphur dioxide.*—Most easily evolved by burning sulphur. It decomposes hydrogen sulphide ($SO_2 + 2SH_2 = 3S + 2OH_2$), and also combines with ammonia. It has also been supposed to act powerfully upon organic matter (Graham), and probably does so if ammonia is not present. Guyton-de-Morveau, who studied the action of this acid, was of opinion that it completely disinfects miasms, and gives some evidence on this point. It must be used in large quantity.

Hydrochloric Acid.—The fumes of this acid were used by Guyton-de-Morveau, and at one time they were much employed, but the action of chlorine is so much more powerful that they are now seldom used.

Carbolic Acid.—This substance is given off when solid carbolic acid is placed in a saucer, or when the liquid acid and water are sprinkled about, or, still better, when one part of the acid and two of ether are allowed to evaporate. It is difficult to measure its action, as it decomposes solution of potassium permanganate, which cannot therefore be used as a measure of the organic impurity of air when carbolic acid vapors are present.

Dr. Sansom [1] has shown that when the acid evaporates, 1 grain of carbolic acid is taken up, at different temperatures, by the following amounts of air, viz., by 320.75 cubic inches at 50° Fahr., by 159.44 cubic inches at 60° Fahr., and by 93.75 cubic inches at 70° Fahr. Vaporizers for carbolic acid fumes have been made, by means of which carbolic acid falls, drop by drop, on a hot metal plate.[2] Dr. Langstaff [3] has invented a trough, containing flannel wetted with water and carbolic acid (1 part of acid and 20 of water), which is placed in the inlet ventilating tubes; he finds that at a temperature of 57°, four ounces of water are taken up in twenty-four hours, and this will keep the air of a room, 22 feet by 10 and 11 feet high, thoroughly impregnated with the odor. Carbolic acid conceals all odors, though it will not destroy hydrogen sulphide if it exists; it lessens the rapidity of putrefaction of animal substances suspended in a room, and they also dry faster, according to Langstaff. It also rapidly arrests the growth of fungi, though it will not completely destroy them; for example, some fresh fecal matter, free from urine, was put in a bottle, and air washed in strong sulphuric acid drawn over it; fungi appeared rapidly on the fecal matter. Air impregnated with carbolic acid was then passed over the fungi; they became discolored, brownish, and apparently died; but on again substituting washed air, they revived. The rapid destruction, and the as rapid recovery and regrowth, could be repeated many times, and showed that the carbolic acid air had withered without actually killing the fungi.

The small growing cells suspended in the air are also stopped in their growth (according to Trautman); and, in fact, the action of carbolic acid may be said to be restraint of putrefaction and limitation of growth of low

[1] The Antiseptic System, by A. E. Sansom, M.D., 1871, p. 15.
[2] Savory & Moore's vaporizer is figured by Sansom.
[3] Hospital Hygiene, by Charles Langstaff, M.D., 1872, p. 20.

forms of aërial life.[1] The exact mode in which it acts is uncertain. When in some quantity, it coagulates albumen ; and it has been supposed to be in this way that it restrains putrefaction.[2]

A mixture of 1 part of carbolic acid and 9 of vinegar, and a little camphor, has been used as a disinfectant in cabins on board ship.

Coal-tar and Bitumen Fumes.—This is an old plan much used in the last century ; the fumes contain carbolic and cresylic acids with other substances, and it is presumed have the same effect as carbolic acid. The substance employed by Süvern, and which has had some reputation in Germany, owes its success as an air-purifier to the fumes of coal-tar.

Vinegar and Ammonia.—The vapor of vinegar is an old remedy, and was much employed by Howard in the purification of jails ; the efficient agents were probably heat and ventilation, which Howard made use of at the same time. The vinegar would, of course, neutralize any ammoniacal vapors which might be in the air ; whether its action would extend beyond this is doubtful.[3]

The vapor of ammonia would not *a priori* seem likely to be a purifier, though, as it restrains decomposition in solid matters, its vapor may have an effect in the air.

It will be observed that the chief gases attacked by the air-purifiers are hydrogen and ammonium sulphide, which are easily destroyed by several agents, especially by chlorine, iodine, and sulphurous acid gas.

The opinion that the floating organic vapors or molecules of whatever kind in the air are destroyed by the air-purifiers, has been hitherto derived not from direct quantitative determination of the organic matter before and after the action of the purifiers, but from their influence on odors and on other organic substances where their action is more easily followed. But the analogical evidence is so strong that we can have little doubt of the reality of the action. Von Nägeli, however, denies the possibility of effecting the destruction of disease-germs by fumigation of any kind.[4]

The mode of action of the air-purifiers may be conceived to vary. Ozone and nitrous acid will directly oxidize all substances which can be so acted upon. Chlorine may act by substitution for hydrogen, or it may take hydrogen and oxidize indirectly by liberating oxygen ; bromine and iodine may also take hydrogen in the same way. Sulphurous acid more probably deoxidizes and forms sulphuric acid. In other cases, it seems probable that neither substitution nor oxidation nor the reverse takes place, but that the action is one of restraint of putrefaction and of limitation of the growth of cryptogamic life. At least this may be inferred from the experiments of Crookes, Lemaire, and others on the action of carbolic acid on low forms of life growing in liquids. In practically carrying out aërial purification, great care is necessary to ensure that the gas or vapor is diffused everywhere through the room, and that it is constantly present.

Purification of Rooms after Infectious Diseases.—In addition to thorough cleansing of all wood-work with soft soap and water, to which a little carbolic acid has been added (1 pint of the common liquid to 3 or 4 gallons of water), and to removal and washing of all fabrics which can be removed, and brushing of the walls, the room should be fumigated for three hours with the fumes of either sulphurous or nitrous acids. Both of these are

[1] Lemaire, Crookes, Sansom, and others.

[2] Various other hydrocarbons probably act in the same way, as, for instance, the terebene proposed by Dr. Bond, of Gloucester, and Jeyes' Perfect Purifier.

[3] It may perhaps delay putrefaction and the growth of minute organisms.

[4] Die Niederen Pilze, pp. 154, 202, 203.

believed to be superior to chlorine, especially in small-pox. All doors and windows and the chimney being closed, and curtains taken down, sulphur is put in a metallic dish, a little alcohol is poured on it, and it is lighted. The proportions should be 1 lb of sulphur for every 1,000 cubic feet of space; and in a long room, it is best to have the sulphur in two or more places. After three hours the doors and windows should be opened, and kept open for twenty-four or thirty-six hours.

Letheby gives a much larger proportion, viz., ½ ounce for every 10 cubic feet. Even this is not an excessive amount. The quantity given above yields little more than 1 per cent. to the quantity of air. Thus—1 lb of sulphur produces 11.7 cubic feet of sulphurous acid gas, and this diluted with 1,000 cubic feet of air gives only 1.17 per cent. Half an ounce of sulphur yields 0.366 of a cubic foot of the gas, and this for 10 cubic feet of air gives 3.66 per cent. Baxter found that 0.194 to 1 per cent. destroyed the reproductive power of septic microzymes in an albuminous or aqueous medium, but with 0.58 per cent. the poison of infective inflammation was still active. Vaccine was destroyed after 10 minutes' exposure to an atmosphere *saturated* with SO_2, whilst chlorine, or carbolic acid, took 30 minutes' exposure. He concludes that for aërial disinfection SO_2 is the most convenient, but that the air should be *saturated* with it.

A lamp has been proposed by Messrs. Price & Co., in which disulphide of carbon is burned. This seems, from experiments made at Netley by Professor Macdonald, to be efficacious, but the extreme inflammability of the substance may be a source of danger. An ounce burned in 53 cubic feet arrested the movements of putrefactive *Bacteria* in a meat infusion in a saucer; it also made the infusion acid, but after some hours *Bacteria* were again in active motion. The amount of SO_2 evolved in the air was 1.16 per cent.

In whitewashed rooms the walls should be scraped, and then washed with hot lime to which carbolic acid is added.

Mortuaries and dead-houses are best purified with nitrous acid or chlorine.

In a sick-room the vessel from which it is disengaged should be some little distance above the bed, or, in some cases, underneath it. In hospitals with inlet tubes, it should be in the inlet tubes; whatever be the agency, there should be a slight odor always perceptible.

It ought to be clearly understood that anything like effectual *disinfection* is only possible by fumigation when the air is rendered irrespirable for the time. Therefore any attempt whilst a room is in actual occupation can only be successful in deodorizing; experiment having shown that minute organisms are not destroyed by anything short of poisonous doses which would prove fatal to man or the higher animals. If, however, the germs of disease are (as is suspected) much more vulnerable than ordinary putrefactive *Bacteria*, partial fumigation, such as may be employed in a sick-room, may do some good. Even the deodorization alone will be an advantage, but it is well not to depend too much upon it as a *disinfectant*, and so permit it to engender a false security, or allow it to interfere with complete and perfect ventilation.

With regard to the effect of chemical reagents on low forms of vegetable and animal life, the works of Sansom,[1] of Dr. Dougall,[2] and the papers

[1] The Antiseptic System, by A. E. Sansom, M.D., 1871.

[2] On the Relative Power of Various Substances in Preventing the Germination of Animalculæ, by John Dougall, 1871.

of Calvert[1] may be consulted; it need only be mentioned here that, according to Dougall,[2] the most powerful agents in destroying "animalculæ" are the following substances:—Sulphate of copper, chloride of aluminum, chromic acid, and dichromate of potassium, dichloride of mercury, benzoic acid, bromal hydrate, chloral hydrate, hydrocyanic acid, alum, hydrochlorate of strychnia, ferrous sulphate, arsenious acid, picric acid, and others which are less efficacious.

Picot[3] has stated that silicate of soda, even in very small quantity, arrests putrid fermentation and retards other fermentations, and is very useful in the treatment of blennorrhagic urethral discharge in women. It also opposes the transformation of glucose and of the glycogenous matters of the liver. If silicate of soda has such an effect, may not some of the other silicates be also active in this way, and may not the antiputrescent power of some soils be thus produced? Lex found the movements of *Bacteria* to be best arrested by chloroform, carbolic acid, prussic acid, and strong solutions of quinine, in the order named. Dr. O'Nial, C.B. (Deputy Surgeon-General), made many experiments on the time of appearance of *Bacteria* in extract of meat and other menstrua.[4] He found, like Dougall, the potassium dichromate to be the most powerful agent in preventing the appearance of *Bacteria*, and after it, but far below, is carbolic acid; yet neither was quite efficacious. The sodium disulphite was found to be of no value, and permanganate of potassium, though a good deodorant, had scarcely any restraining effect on the formation of *Bacteria*. Commercial chlor-alum was of little use, but a strong solution of chloride of aluminum was fairly effectual. The paper must be consulted for many details, but it shows clearly how little *Bacteria* can be influenced by our present modes of using these "chemical disinfectants." See also Baxter's Paper.[5]

From a number of experiments made at Netley by Drs. Macdonald, Notter, and de Chaumont,[6] the conclusions arrived at were that disinfectants required to be in poisonous quantity before they affected low forms of life, such as *Bacteria*. Similar conclusions have been arrived at by Lebon.[7] At the same time, he points out that there is little or no parallelism between action on ordinary *Bacteria* and disinfection. Thus potassium permanganate is a disinfectant, but has little action on *Bacteria*; alcohol, on the other hand, prevents the development of the latter, but is no disinfectant.

5. DISINFECTION IN VARIOUS DISEASES.

Exanthemata, Scarlet Fever, and Rötheln.—The points to attack are the skin and the throat. The skin should be rubbed, from the very commencement of the rash until completed desquamation, with camphorated oil, or oil with a little weak carbolic acid. The throat should be washed with Condy's fluid, or weak solution of sulphurous acid. Clothes to be baked, or to be placed at once in boiling water, to every gallon of which 2 ounces of commercial chloride of lime, or 1 ounce of sulphate of zinc, or ½ fluid-

[1] Proceedings of the Royal Society, vol. xx., p. 185.
[2] Op. cit., table, p. 6.
[3] Comptes Rendus, December, 1872.
[4] Army Medical Department Report for 1871, vol. xlii. (1873).
[5] Reports of the Medical Officer of the Privy Council and Local Government Board, new series, No. vi., p. 216.
[6] Report on Hygiene, Army Medical Reports, vol. xx., 1880.
[7] Comptes Rendus, Juillet 1882, p. 250.

ounce of chloride of zinc, is added. The clothes should not be washed at a common laundry.

Chlorine or euchlorine may be diffused in the air, the saucer being put some little distance above the head of the patient. Carbolic acid and ether or carbolic acid spray may be used instead.

In this, as in all cases, there can be no use in using aërial disinfectants, unless they are constantly in the air, so as to act on any particle of poison which may pass into the atmosphere.

Small-pox.—The skin and the discharges from the mouth, nose, and eyes are to be attacked. There is much greater difficulty with the skin, as inunction cannot be so well performed. But smearing with oil and a little carbolized glycerine, or in difficult cases applying carbolized glycerine to the papules and commencing pustules, might be tried. The permanganate and sulphurous acid solutions should be used for the mouth, nose, and eyes. The clothing should always be baked before washing, if it can be done. The particles which pass into the air are enclosed in small dried pieces of pus and epithelial scales; and Bakewell, who has examined them, expresses great doubt whether any air-purifier would touch them.

Measles.—Oily applications to the skin and air-purifiers, and chloride of zinc or of aluminum in the vessels receiving the expectoration, appear to be the proper measures.

Typhus (*exanthematicus*).—Two measures seem sufficient to prevent the spread of typhus—viz., most complete ventilation and immediate disinfection and cleansing of clothes. But there is also more evidence of use from air-purifiers than in the exanthemata. The nitrous acid fumes were tried very largely toward the close of the last century and the beginning of this, in the hulks and prisons where Spanish, French, and Russian prisoners of war were confined.[1] At that time, so rapidly did the disease spread in the confined spaces where so many men were kept, that the efficacy even of ventilation was doubted, though there can be no question that the amount of ventilation which was necessary was very much underrated. Both at Winchester and Sheerness the circumstances were most difficult; at the latter place (in 1785), in the hulk, 200 men, 150 of whom had typhus, were closely crowded together; 10 attendants and 24 men of the crew were attacked; 3 medical officers had died when the experiments commenced. After the fumigations, one attendant only was attacked, and it appeared as if the disease in those already suffering became milder. In 1797 it was again tried with success, and many reports were made on the subject by army and naval surgeons. It was subsequently largely employed on the Continent,[2] and everywhere seems to have been useful.

These facts lead to the inference that the evolution of nitrous acid should be practised in typhus fever wards, proper precautions being taken to diffuse it equally through the room, and in a highly dilute form.

Hydrochloric acid was employed for the same purpose by Guyton-de-Morveau, in 1773, but it is doubtless much inferior to nitrous acid. Chlorine has been also employed, and apparently with good results.[3]

In typhus it would seem probable that the contagia pass off constantly by the skin; at least, the effect of ventilation, and the way in which the

[1] It was used at Winchester in 1780 by Carmichael Smith, and again at Sheerness in 1785. Smith published several accounts.—An account of the Experiment made at the desire of the Lords Commissioners of the Admiralty, by J. C. Smith, 1796.

[2] Chevallier, Traité des Désinfectants, pp. 39, 40.

[3] Ibid., pp. 14, 15.

agent adheres to body linen, seem to show this. The agent is not also enclosed in quantities of dried discharges and epidermis, as in the exanthemata, and is therefore less persistent, and more easily destroyed, than in those cases. Hence possibly the greater benefit of fumigations, and the reason of the arrest by ventilation. The clothes should be baked, steeped, and washed, as in the exanthemata.

Bubo Plague.—The measures would probably be the same as for typhus.

Enteric (Typhoid) Fever.—The bowel discharges are believed to be the chief, if not the sole, agents in spreading the disease; effluvia from them escape into the air, and will adhere to walls, and retain power for some time, or the discharges themselves may get into drinking water. Every discharge should be at once mixed with a powerful chemical agent; of those, chloride and sulphate of zinc have been chiefly used, but sulphate of copper (which Dougall found so useful in stopping the growth of animalculæ), chloride of aluminum,[1] nitrate of lead, strong solution of ferrous sulphate (1 ounce to a pint of water), or carbolic acid.[2] After complete mixing, the stools must be thrown into sewers in towns; but this should never be done without previous complete disinfection. In country places they should be deeply buried at a place far removed from any water supply; they should never be thrown on manure heaps or into middens, nor into earth-closets, if it can possibly be avoided. As the bed-clothes and beds are so constantly soiled with the discharges, they should be baked, or if this cannot be done, boiled immediately after removal with sulphate or chloride of zinc. It would be less necessary to employ air-purifiers in this case than in others.

Cholera.—There can be little doubt that the discharges are here also the active media of conveyance of the disease, and their complete disinfection is a matter of the highest importance. It is, however, so difficult to do this with the immense discharges of cholera, especially when there are many patients, that the evidence of the use of the plan in the last European epidemic is very disappointing.

The ferrous sulphate (green vitriol), which has been strongly recommended by Pettenkofer as an addition to the cholera evacuations, was fully tried in 1866 at Frankfort, Halle, Leipzig, in Germany, and at Pill, near Bristol,[3] and in those cases without any good result. In other places, as at Baden, the benefit was doubtful. It seemed to answer better with Dr. Budd and Mr. Davies at Bristol, but other substances were also used, viz., chlorine gas in the rooms, and chloride of lime and Condy's fluid for the linen. On the whole, it seems to have been a failure.[4] Ferric sulphate, with or without potassium permanganate, has been recommended by Kühne, instead of ferrous sulphate, but there does not appear to be any evidence on the point. Carbolic acid was largely used in England in 1866, and appeared in some cases to be of use, as at Pill, near Bristol, and

[1] In speaking of chloride of aluminum, reference is always made to the strong solution, and not to the commercial "chor-alum," which, though useful in various ways, is yet a weak solution.

[2] Or a mixture of two or more (Budd). Be lavish (says Budd) in the use of chemicals, rather than run the terrible risk of failing by default.

[3] Tibbets, Medical Times and Gazette, October, 1867.

[4] In Dr. Parkes' experiments on sewage putrefaction (Army Med. Reports, vol. viii., p. 318), ferrous sulphate had very little action in preventing putrefaction, and the Committee of the Berlin Medical Society declined to recommend it for cholera, as they found it did not prevent fermentative action.

perhaps in Southampton. It failed at Erfurt, but as it is believed the wells were contaminated by soakage,[1] this is perhaps no certain case. Chloride of lime and lime were used at Stettin without any good result, and, on the whole, it may be said that the so-called disinfection of the discharges of cholera does not seem to have been attended with very marked results. At the same time, it cannot be for a moment contended that the plan has had a fair trial, and we can easily believe that unless there is a full understanding on the part of both medical men and the public, of what is to be accomplished by this system, and a conscientious carrying out of the plan to its minutest details, no safe opinions of its efficacy or otherwise can be arrived at. It would be desirable to try the effect of chromic acid or potassium dichromate.

With regard to air-purifiers, little evidence exists. Chlorine gas, diffused in the air, was tried very largely in Austria and Hungary in 1832, but without any good results. Nitrous acid gas was used at Malta in 1865, but apparently did not have any decided influence, although Ramon de Luna has asserted that it has a decided preservative effect, and that no one was attacked in Madrid who used fumigations of nitrous acid. But negative evidence of this kind is always doubtful. Charcoal in bulk appears to have no effect; Dr. Sutherland saw a ship's crew severely attacked, although the ship was loaded with charcoal.

Carbolic acid vapor diffused in the atmosphere was largely used in 1866 in England; the liquid was sprinkled about the wards, and sawdust moistened with it was laid on the floors and under the patients. The effect in preventing the spread of the disease was very uncertain. The lighting of sulphur fires in infected districts has been recommended in India.

Yellow Fever.—In this case the discharges, especially from the stomach, probably spread the disease, and disinfectants must be mixed with them. Fumigations of nitrous acid were employed by Ramon de Luna,[2] and it is asserted that no agent was so effectual in arresting the spread of the disease.

Dysentery.—It is well known that dysentery, and especially the putrid dysentery, may spread through an hospital from the practice of the same close stools or latrines being used. As long ago as 1807 fumigations of chlorine were used by Mojon,[3] to destroy the emanations from the stools, and with the best effects. The chlorine was diffused in the air, and the stools were not disinfected; but this ought to be done, as in enteric fever, and especially in the sloughing form. It is probable that carbolic acid in large quantity would be efficacious.

With respect to *Erysipelas, Diphtheria, Syphilis, Gonorrhœa, Glanders,* and *Farcy,* local applications are evidently required, and carbolic acid in various degrees of strength, and the metallic salts, are evidently the best measures.[4]

[1] Ninth Report of the Medical Officer to the Privy Council.

[2] Ann. d'Hygiène, April, 1861.

[3] His words, as quoted by Chevallier, are interesting:—"The dysentery became contagious in the Hospital at Genoa; almost all the sick in my division, nearly 200, were attacked); and as we know that this disease, when contagious, is communicated ordinarily from one person to another by the abuse which exists in all hospitals of making the same latrines serve for all the sick of a ward, I wished to see if fumigations of chlorine had the power of destroying these contagious exhalations. I therefore caused fumigations to be used twice daily in the latrines, and, in a few days, I was able to destroy that terrible scourge, which already had made some victims."

[4] Davaine finds iodine most powerful in destroying the infection of malignant pustule, $\frac{1}{1000}$th part being effectual. It may be injected into the skin without injury (Comptes Rendus, September and October, 1873). See also Report on Hygiene, Army Med. Reports, vol. xiv., in which its use in snake bite is suggested.

Cattle Plague.—The experiments made by Mr. Crookes on the disinfectant treatment of cattle plague with carbolic acid vapor have an important bearing on human disease. Although the observations fall short of demonstration, there are grounds for thinking that when the air was kept constantly filled with carbolic acid vapor, the disease did not spread. So also euchlorine was employed in Lancashire by professor Stone, of Manchester, and with apparent benefit. Dr. Moffat employed ozone (developed from phosphorus exposed to the air), and he believes with benefit.[1] As such experiments are very much more easily carried out on the diseases of animals than on those of men, it is much to be wished that the precise effect of the so-called disinfectants should be tested by continuing the experiments commenced by Mr. Crookes, not only in cattle plague in the countries where it prevails, but in epizootic diseases generally.

Among other substances which may be used are *Jeyes' Perfect Purifier* and *Little's Absolute Phenol*, both coal-tar preparations; *Sporokton*, a concentrated solution of sulphurous acid; and many others.

6. DEODORIZATION OF SEWAGE.

A very great number of substances have been added to sewage for the purpose of preventing decomposition and retaining the ammoniacal compounds.

1. *Charcoal*, which soon, however, gets clogged and loses its power; it is not nearly so useful when used in this way as in the purification of air. When in relatively large quantity it decomposes the ammonia and sets nitrogen free, and so diminishes the agricultural value. Sillar's preparation (A, B, C deodorant) is a mixture of animal charcoal, blood, clay, and alum refuse. Under the name of native guano, the resulting product seems to be of value. Messrs. Weare & Co.'s is also a charcoal process.

2. *Dry Earth*, especially humus, and marly and clayey soils; the effect is similar to that of charcoal, but it is not so soon clogged. Bird's preparation is ferruginous clay, moistened with sulphuric acid, and then dried and pulverized.

3. *Quicklime* is sprinkled over the solid excreta, or quicklime and water added to sewer water, till a deposit occurs, leaving a clear fluid above. This is a very imperfect method, and the solid deposit has little or no value as a manure.

From 15 to 16 grains of quicklime are enough for 1 gallon of sewage, or 20 cwt. per million gallons. At Leicester 580 tons of quicklime were used per annum for 4,700,000 tons of sewage. The process has now been discontinued there, but is still partially employed at Birmingham and elsewhere.

Hanson's process consists in the use of slaked lime and black ash refuse, or the soda and tank waste from the alkali works, mixed with sulphuric acid.

4. Cheap salts of *alumina*, and then lime, or alum sludge, lime, and waste animal charcoal (Manning), or zinc and charcoal (Stothert's process), A, B, C (Sillar's process), chloride of aluminum (chlor-alum).

The alumina precipitated by the lime forms a very bulky precipitate, well suited to the entanglement of suspended matters. The clearance of the sewage is more perfect than with lime alone, but otherwise the process

[1] On Meteorology in Reference to Epidemic and Sporadic Cholera, by F. Moffat, M.D., Hawarden, 1868.

and the objections are the same, and the cost is greater. The whole of the phosphoric acid is precipitated as aluminum phosphate. To a gallon of sewage water there should be added 73½ grains of aluminum sulphate, 3½ grains of sulphate of zinc, 73½ grains of charcoal, and 16¾ grains of quicklime.

Chlor-alum is a weak solution of chloride of aluminum ; it is not a very powerful deodorizer, and must be used in large quantity, but its cheapness and want of poisonous properties [1] are recommendations, and when in sufficient amount it is effectual. It is efficacious against ammonia, but not against hydrogen sulphide ; it acts moderately against fecal odor.

5. *Magnesium Superphosphate and Lime-water* (Blyth's patent).—The idea was to add a substance which, in addition to deodorizing, might be useful as a manure, and it was thought that a double phosphate of magnesium and ammonium would be thrown down ; but this salt is sufficiently soluble in water, especially when the water contains chloride of sodium, to render this expectation incorrect. This method has been practically found to be useless, and to be more costly than any other plan.

6. *F. Hille*,[2] whose process is in use at Wimbledon, the town of Aldershot, and elsewhere, uses a mixture of lime, tar, and salts of magnesium for defecation and deodorizing the sewage. The effluent water is then passed through artificial filters, or used for irrigation purposes. This plan has been well spoken of by Captain Flower[3] and others, and it appears to be moderate in cost compared with most other processes.

7. *Iron Perchloride.*—When this salt is added to sewage, a precipitate of ferric oxide is caused by the ammonium carbonate (which forms so rapidly in sewage), and carries with it all the suspended matters of the sewage. A clear fluid remains above. The hydrogen sulphide falls in the precipitate as iron sulphide. As the sulphide of iron tends to form ferric oxide, sulphur being let free, it has been conjectured by Hofmann that an oxidizing effect from the oxide may follow the first action.

Both precipitate and supernatant liquid are free from odor.

This substance has been tried at Croydon and Coventry. From 14 to 29 grains per gallon of sewage are necessary for London sewage ; for Croydon sewage from 5 to 15 grains were necessary. One gallon of liquid perchloride was sufficient for 15,000 gallons of sewage (Hofman and Frankland).

The perchlorides of iron can be manufactured by dissolving in hydrochloric acid peroxide of iron, the different iron ores, refuse oxide of iron from sulphuric acid works, iron rust in foundries, etc. Another plan is to take equivalent proportions of common salt, sulphuric acid, iron rust, and water, so that chlorine, when disengaged, shall combine with the iron. A hard yellowish, not very deliquescent substance, containing 26 per cent. of perchloride of iron, is formed, which can be transported to any distance. The price, if made in this way, is £2 7s. per ton (cost of labor not included) in England.

The perchloride acts both on hydrogen and alkaline sulphides, in both cases setting free sulphur. In sewage its ordinary action is on ammonium sulphide.

[1] In some samples I have found a considerable amount of lead, but by improved manufacture this (it is said) has since been remedied.—[F. de C.]

[2] System—F. Hille, Sewage Disinfecting and Filtration Process, 2d edition, 1876.

[3] Sewage Treatment, more especially as affecting the pollution of the River Lea, a paper contributed to the Sewage Conference held by appointment of the Council of the Society of Arts, in May, 1876, by Captain L. Flower, Sanitary Engineer, Lea Conservancy Board, etc.

Objections have been made to the perchloride, as it contains arsenic; but the amount of this is small, and as it falls with the deposit it is never likely to be dangerous.

8. *Lueder & Leidloff's Powder* consists (according to Leuchtenberg's analysis) of ferric sulphate, 36 per cent.; ferrous sulphate, 16; free sulphuric acid, 4; calcium sulphate and other substances, 44. It has been highly commended, but, from experiments made at Netley, it does not seem very powerful.

9. *Lead Nitrate*, or *Ledoyen's Fluid*, is made by dissolving 1 pound of litharge in about 7 ounces of strong nitric acid and 2 gallons of water; a little of the water is mixed with the litharge; the acid is gradually added, and then the rest of the water. This quantity will deodorize a moderate-sized cesspool. It acts rapidly on hydrogen sulphide, and can be depended upon for this purpose.

10. *Zinc Chloride.*—Burnett's fluid contains 25 grains to every fluid drachm; 1 pint is added to a gallon of water (1 to 8). It is usually said to decompose hydrogen sulphide until the solution becomes acid, when its action ceases; but Hofmann finds that it does not act on free hydrogen sulphide, but on ammonium sulphide, forming zinc sulphide and ammonium chloride. It destroys ammoniacal compounds and organic matter. The sulphates of zinc and copper decompose free hydrogen sulphide, with formation of metallic sulphide and water.

Burnett's fluid delays decomposition in sewage for some time; but a very peculiar odor is given out, showing that some change is going on. A good effect is produced on hydrogen sulphide by a mixture of zinc and ferrous sulphates (Larnaudès' mixture) which also lessens for the time the peculiar sewage smell.

11. *Zinc Sulphate.*—This forms part of the Universal Disinfecting Powder[1] (Langston-Jones' patent), along with Cooper's salts, viz., calcium and sodium chlorides. This powder has the advantage of being inodorous, but it is not a strong deodorant. It, however, gets rid of fecal odor to some extent, and is efficacious against H_2S.

12. *Potassium permanganate* prevents putrefaction for a short time, and removes the odor from putrefying sewage, but it requires to be used in large quantity.

13. Preparations from *coal-tar; carbolic acid* (phenol or phenic acid, or phenyl-alcohol (C_6H_6O)); coal-tar creosote, and cresylic acid (cresol or cresyl-alcohol (C_7H_8O)), in various admixtures.[2] These substances are all excellent sewage deodorants and arresters of putrefaction.

The last few years have seen an extraordinary development in the manufacture of these substances. Phenol or carbolic acid is now obtained in great purity, and is sold in crystals, and also in a liquid form. All the

[1] Analysis (de Chaumont):—

Water	7.40
Calcium and sodium chlorides	73.20
Zinc sulphate	14.26
Insoluble	5.20
Total	100.06

To later samples some calcium borate was added. Probably the addition of ferrous sulphate might improve it.

[2] It is perhaps unfortunate that phenol and cresol, which are rather alcohols than acids, should have been termed carbolic and cresylic acids. If the terms phenol and cresol could be used instead it would be better.

preparations may be conveniently classed under the three divisions of crystals, liquids, and powders.

(*a*) *Crystals.*—Carbolic acid, more or less pure, is the only substance under this head ; it is so slightly soluble in water (only in the proportion of 5 per cent.) that it is not so useful as a deodorant as the impurer kind. When mixed with sewage it acts slowly and not so perfectly as the impurer kinds. When exposed to the air it liquefies, and is slowly given out into the air, and is then supposed to be useful as an air purifier.

(*b*) *Liquids.*—Carbolic acid, more or less impure, dissolved in water, simply, or with a little alcohol and cresylic acid (cresol), forms the liquid carbolic acids. In the market they are found almost colorless, or highly colored. The various liquids contain from 10 to 90 per cent. of phenol. Cresol, though crystalline and colorless when pure, is usually found in the market as a dark liquid. Some of it, no doubt, exists in most samples of carbolic acid. Owing probably to the way they mix at once with the sewage, the liquid acids are more deodorant than the crystallized acid, and restrain putrefaction for a long time. Carbolic acid, however, does not act on hydrogen sulphide, though it will restrain the processes which produce it.

Samples of so-called carbolic acid are sold, which are only impure tar oils, and almost destitute of deodorizing power. Sometimes a nauseous sulphur compound is also present.

Mr. Crookes[1] gives the following rules in order to determine the presence of the tar oils :—

" Commercial carbolic acid is soluble in from 20 to 70 parts of water, or in twice its bulk of a solution of caustic soda, while oil of tar is nearly insoluble, but if the amount of carbolic acid be increased, some remains undissolved.

" To apply the tests—1. Put a teaspoonful of the carbolic acid in a bottle, pour on it half a pint of warm water, and shake the bottle at intervals for half an hour, when the amount of oily residue will show the impurity ; or dissolve one part of caustic soda in 10 parts of warm water, and shake it up with 5 parts of the carbolic acid. As before, the residue will show the amount of impurity.

" These tests will show whether tar oils have been used as adulterants, but to ascertain whether the liquid consists of a mere solution of carbolic acid in water or alkali, or whether it contains sulpho-carbolic or sulpho-cresylic acids, another test must be used based on the solubility of these, and the insolubility of carbolic acid in a small quantity of water. In this case proceed as follows :—2. Put a wineglassful of the liquid to be tested in a bottle, and pour on it half a pint of warm water. If the greater part dissolves, it is an adulterated article. Test the liquid in the bottle with litmus paper ; if strongly acid, it will show the probable presence of sulpho-acids ; whilst if alkaline, it will show that caustic soda has been probably used as a solvent."

If the quantity of carbolic acid has to be estimated from a liquid, it must be distilled at a given temperature. Carbolic acid boils at 184° C. (= 363° Fahr.), cresol at 203° C. (= 397.4° Fahr.).

In using the liquid acid, 1 part is mixed with 50 or 100 of water, according to the strength of the acid, and thrown down drains or into cesspools, or sprinkled with a watering-can over dung-heaps.

[1] Third Report—Cattle Plague Commission. Carbolic acid can be distinguished from creosote by its solubility in glycerine (Morson).

(*c*) *Powders.*—The two principal carbolic acid powders are M'Dougall's and Calvert's, but there are several others in the market known under various names.

M'Dougall's and Calvert's powders are widely different in composition. The former is strongly alkaline from lime, and makes the sewage alkaline. It consists of about 33 per cent. of carbolate of lime and 59 per cent. of sulphite of magnesia, the rest being water.

Calvert's powder is carbolic acid, about 20 to 30 per cent., mixed with alumina from alum works, and some silica.

The quantity of these preparations which must be used depends on the degree and duration of deodorization wished for. For the daily solid excreta (4 ounces) of an adult at least from 30 to 70 grains of the crystallized acid, 60 drops of the strong liquid (90 per cent. of acid), or ½ ounce of the dilute carbolic acid, sold at 1s. per pint, are necessary, if the sewage is to be kept in an unaltered state for 10 to 20 days, but a smaller amount is sufficient for 2 or 3 days.[1] Dr. Sansom, who does not rate the effect of carbolic acid so highly as a deodorant, also finds that much larger quantities must be used than is usually stated.[2] Half an ounce of either Calvert's or M'Dougall's powder for 4 ounces of sewage has a preservative effect for 18 to 20 days ; ¼ ounce or less is effectual for 3 or 4 days, but if the stools contain urine much more is necessary.[3]

Smaller quantities can, however, be used, if diminution, but not entire removal of smell and putrefaction is desired. Quicklime 5 parts, and carbolic acid 1 part, make a good deodorizing mixture. If hydrochloric acid is added, and then water, the lime is deposited, and the carbolic acid floats on the surface, and its amount can be determined.

14. *The Süvern Deodorant.*—The water flowing from sugar factories has long been a source of annoyance and ill-health ; it contains quantities of vegetable organisms (*Oscillaria alba* or *Beggiatoa*), which act like ferments, and rapidly decompose the sulphates in the water, and liberate hydrogen sulphide. Herr Süvern, to remedy this, proposed a preparation of coal-tar thus prepared.[4] A bushel and a half of good quicklime is put in a cask and slaked ; it is well stirred, and 10 lb of coal-tar are thoroughly mixed with it, so that the coal-tar may be thoroughly divided. Fifteen pounds of magnesium chloride dissolved in hot water are then thoroughly mixed with the mass, and then additional hot water is added, enough to make a mass of just sufficient liquidity to drop slowly from a stick inserted in it and then pulled out. The magnesium chloride forms deliquescent calcium chloride, magnesia being liberated, and it is found that this prevents the caking of the deodorant and the adherence to pipes. This deodorant has come into considerable use for cesspools, drains, etc. The Müller-Schurr deodorizer has been already noticed.

15. Dr. F. T. Bond (of Gloucester) has introduced a new deodorant in the form of powder and liquid, consisting essentially of metallic salts,

[1] See Dr. Parkes' experiments in the Army Medical Department Report, vol. viii., p. 318.

[2] Op. cit., p. 203.

[3] Dr. John Day (of Geelong) published a paper in the Australian Medical Journal (June, 1874), on the comparative value as disinfectants of carbolic acid and mineral oils, such as gasolene and kerosene. He prefers gasolene, and finds it may be used for papered walls, furniture, clothing, and flooring. It must be used with caution near lights, as it is very inflammable. Dr. Day attributes its action to its strong oxidizing properties ; paper brushed over with it gave the reaction of peroxide of hydrogen after more than a year.

[4] Trautman, Die Zersetzungsgase, 1869, p. 35.

alum, and *terebene* (a hydrocarbon derived from turpentine by treatment with sulphuric acid). Terebene has a pleasant odor, and so far is superior to carbolic acid ; its deodorizing powers are very considerable. The preparations in the form of powder are various, the chief being *ferralum* and *cupralum*, the latter being most frequently employed. It consists of copper sulphate, aluminum sulphate, a little potassium dichromate, and terebene. It is a very powerful deodorant, counteracting ammonia and hydrogen sulphide, and at least masking fecal odor as much as carbolic acid. Some objections were formerly made to it on account of a tendency to deliquescence, due to the presence of sodium chloride. This has now been remedied, and the preparation keeps well.

The substance advertised as *Sanitas* is a hydrocarbon derived from turpentine acted upon by steam. It has the advantage of being easily miscible with water, but it is not very powerful.

16. The remarkable power shown by *salicylic acid* in arresting fermentation, and its value in the antiseptic treatment of wounds, would seem to indicate it as a good agent, but it is at present too expensive for use on a large scale.

General Conclusion.—It must be remembered that deodorization is only possible within certain limits, and that in a number of cases only partial results can be obtained, unless very large quantities of the deodorant are used.[1] The most effectual appear to be the terebene preparations, especially the cupralum, and carbolic acid and its preparations. Of these the cupralum has the advantage of destroying hydrogen sulphide and neutralizing ammonia, which are only masked by the others. Chloride of lime and chloride of soda are also powerful, but have themselves a sickly odor, very disagreeable to many persons. The Süvern deodorant is probably the next best, and after that the ferric chloride ($FeCl_3$).

[1] In experimenting with the very offensive infusion of linseed, it was found almost impossible to get rid of odor without using very large quantities of the deodorants.—[F. de C.]

CHAPTER XX.

STATISTICS.

An accurate basis of facts, derived from a sufficient amount of experience, and tabulated with the proper precision, lies at the very foundation of hygiene, as of all exact sciences. Army surgeons have already contributed much important statistical evidence as to the amount and prevalence of different diseases, and it is evident that no other body of medical practitioners possess such opportunities of collecting, with accuracy, facts of this kind, both among their own nations and others. As they have to make many statistical returns, it seems desirable to make a few brief remarks on some elementary points of statistics, which are necessary to secure the requisite accuracy in collecting and arranging facts. But it is, of course, impossible to enter into the mathematical consideration of this subject; for a separate treatise would be required to do justice to it.

SECTION I.

A FEW ELEMENTARY POINTS CONNECTED WITH GENERAL STATISTICS.

1. The elements of statistical inquiries are individual facts, or so-called numerical units, which having to be put together, or classed, must have precise, definite, and constant characters. For example, if a number of cases of a certain disease are to be assembled in one group with a definite signification, it is indispensable that each of these cases should be what it purports to be, an unit not only of a definite character, but of the same character as the other units. In other words, an accurate diagnosis of the disease is essential, or statistical analysis can only produce error. If the numerical units are not precise and comparable, it is better not to use them. A great responsibility rests on those who send in inaccurate statistical tables of diseases; for it must be remembered that the statist does not attempt to determine if his units are correct; he simply accepts them, and it is only if the results he brings out are different from prior results that he begins to suspect inaccuracy.[1]

[1] It is in vain to conceal the fact that many persons look at tables of diseases collected indiscriminately as worse than useless, from errors in diagnosis. Even in the army returns, which are all furnished by qualified practitioners, there is reason to doubt the correctness of the earlier tables especially. But it is believed that the army returns of diseases are now gaining in accuracy, and it cannot be too strongly urged on medical officers that perfect accuracy in diagnosis is a duty of the highest kind. It is much better to have a large heading of undetermined diseases than, when in doubt, to put a case of disease under a heading to which it has no unequivocal pretensions. It is greatly to be regretted that, from the abridged form in which they are now published, much valuable information is now no longer obtainable from the Army Medical Reports.

2. These items or numerical units being furnished to the calculator, are by him arranged into groups; that is to say, he contemplates the apparently homogeneous units in another light, by selecting some characteristic which is not common to all of them, and so divides them into groups. To take the most simple case: A certain number of children are born in a year to a given population. The children are the numerical units. They can then be separated into groups by the dividing character of sex, and then into other groups by the dividing character of "born alive," or "still-born," etc.

Or, a number of cases of sickness being given, these numerical units (all agreeing in this one point, that health is lost) are divided into groups by diseases, etc.; these groups, again, are divided into others by the character of age, etc., and in this way the original large group is analyzed, and separated into minor parts.

This group-building seems simple, but to properly group complex facts, so as to analyze them, and to bring out all the possible inferences, can only be done by the most subtle and logical minds. The dividing character must be so definite as to leave no doubt into which group an unit shall fall; it must be precise enough to prevent the possibility of an unit being in two groups at the same time. This rule is of the greatest importance, and many examples could be pointed out of error from inattention to it.

Having decided on the groups, their numerical relations are then expressed in figures, for example:—

3. In order to express the relation of the smaller groups to the gross number of individual facts or units, a constant numerical standard must be selected, else comparison between groups of unequal numbers cannot be made. The standard universally adopted in medical statistics is to state this relation as a percentage, or some multiple of a percentage. So much per cent., or per 1,000, or per 10,000, is the standard. This is got simply by multiplying the number of units in the smaller groups by 100, and dividing by the total number of units. Thus, let us say there occur 362 cases of pneumonia; this is divided into two groups of recovered or died, say 343 recoveries and 19 deaths; and their relation may be expressed in one of two ways, viz., either by the relation of the deaths to the total number of cases, which will be—

$$\frac{19 \times 100}{362} = 5.25 \text{ per cent.}$$

of mortality; or by the relation of the deaths to recoveries, viz.—

$$\frac{19 \times 100}{343} = 5.54 \text{ per cent.}$$

4. Having established that in a certain number of cases, divided into groups, the number in each group bears a certain proportion to the whole, how far are we justified in concluding that the same proportions will be repeated in future cases? This will chiefly depend on the number of the cases. If the number of cases from which one proportion has been taken is small, we can have no confidence that the same proportion will be repeated in future cases. If the number is large, there is a greater probability that the proportion in succeeding numbers of equal magnitude will be the same. The result obtained even from a very large number is, however, only an approximation to the truth, and the degree in which it approaches the truth can be obtained by calculation. The following rule

is given by Poisson for calculating the limits of error, or, in other words, the degree of approximation to the truth :—

Let μ be the total number of cases recorded,
m be the number in one group,
n be the number in the other,
So that $m + n = \mu$.

The proportion of each group to the whole will be respectively $\frac{m}{\mu}$ and $\frac{n}{\mu}$, but these proportions will vary within certain limits in succeeding instances. The extent of variation will be within the proportions represented by

$$\frac{m}{\mu} + 2\sqrt{\frac{2.m.n}{\mu^3}}$$

and [1]

$$\frac{m}{\mu} - 2\sqrt{\frac{2.m.n}{\mu^3}}$$

It will be obvious that the larger the value of μ the less will be the value of $\sqrt{\frac{2.m.n}{\mu^3}}$, and consequently the less will be the limits of error in the simple proportion $\frac{m}{\mu}$.

An example will show how this rule is worked. The following is given by Gavarret :—[2]

Louis, in his work on "Typhoid Fever," endeavors to determine the effect of remedies, and gives 140 cases, with 52 deaths and 88 recoveries. What is the mortality per cent., and how near is it to the true proportion ?

$m = 52$ = number of deaths,
$n = 88$ = number of recoveries,
$\mu = 140$ = total number of cases,

i.e., 37 deaths in 100 cases, or more precisely 37,143 deaths in 100,000 cases. How near is this ratio to the truth ? The possible error is as follows—the second half of the formula, viz. :—

$$2\sqrt{\frac{2.m.n}{\mu^3}}$$

will be

$$2\sqrt{\frac{2\times 52\times 88}{(140)^3}} = 0.11550 \text{ to unity.}$$

(Or 11,550 in 100,000.)

The mortality being 37.143 per cent., or 37,143 deaths in 100,000 cases. in these cases, it may be in other 140 cases either

$$37{,}143 + 11{,}550 = 48.693 \text{ per cent.}$$

or $37{,}143 - 11{,}550 = 25.593$ "

In other words, in successive 140 cases the mortality will range from 49 per

[1] This is sometimes stated thus:—

$$\frac{p}{q} + \sqrt{\frac{8\,p(q-p)}{q^3}};$$

when q = total number of events,
and p = total number of events in any particular direction.

[2] Statisque Médicale, 1840, p. 284.

cent. (nearly) to 26 per cent. (nearly), so that Louis's numbers are far too few to give even an approximation to the true mean.

5. There being a number of facts, each of which can be expressed by a numerical value, an average or mean number is obtained by adding all the numerical values, and dividing by the number of facts.[1] This gives the common or *arithmetical* mean, which can be shown mathematically to be the nearest to the truth in physical inquiries. Its degree of approximation may be determined by working out the probable error ;[2] the smaller the latitude of error the more trustworthy the series from which the mean number is drawn. To compare two or more similar groups together, the probable error of each may be ascertained, the relative values being as the reciprocals of the squares of the probable errors ; that is $\frac{1}{(pe)^2}$, where (pe) is the probable error. Thus if we have two groups, A and B, A having a probable error of 10 per cent. and B one of 2 per cent., the value of A will be $\frac{1}{10^2} = \frac{1}{100}$, and the value of B will be $\frac{1}{2^2} = \frac{1}{4}$, or the group B will have a value 25 times as great as A.

The relative values of two or more series are also as the square roots of the numbers of units of observation. So also, by increasing the number of observations in any inquiry, the value (or accuracy) increases as the square root of the number.

Thus a group of 10 observations is to a group of 100 as $\sqrt{10}$ to $\sqrt{100}$, or as 3.16 to 10.

In many cases the method by successive means is very useful. This consists in taking the mean of the mean numbers successively derived from a constantly repeated series of events (say the mortality to a given population yearly). Supposing, for example, the annual mortality in England to be, in successive years, 22, 23, 21, 26, 23, 21, 22, 28, 22, 21, per 1,000 living, the successive means would be—

$$\frac{22+23}{2} \quad \frac{22+23+21}{3} \quad \frac{22+23+21+26}{4},$$

and so on, until the numbers are so great as to give every time the same result. It is useful to calculate the successive means in both the direct

[1] The *arithmetical* mean is used in medical inquiries ; but there are, in addition, the *geometrical*, *harmonic*, and *quadratic* means. For an account of these, and for many rules, reference may be made to Dr. Bond's translation of Professor Radicke's Essay, New Sydenham Society Publ., vol. xi.

[2] To find the *mean error* :—1. Find the *mean* of the series of observations ; find the *mean* of all the observations *above* the mean, and subtract the mean from it, this gives the mean error in excess. 2. Find the *mean* of all the observations *below* the mean, and subtract the latter from this mean, this gives the mean error in deficiency. Add the two quantities, and take the half, this is the *mean error*.

To find the *error of mean square* :—Square each of the observations and add them together, subtract from this sum the square of the mean, multiplied by the number of observations, then, calling this remainder (S), and the number of observations (n), we have :—

$$\text{Error of mean square, } \left\{ \begin{array}{ll} \text{Of a single measure, } & \sqrt{\frac{S}{n-1}}, \\ \text{Of the result, } & \sqrt{\frac{S}{n(n-1)}}. \end{array} \right.$$

The *probable error* is obtained by taking two-thirds (nearly) of the mean error or error of mean square, the actual ratio being 1 : 0.6745.

and inverse order, viz., from first to last, and then from last to first, i.e., putting the two last together, then the three last, etc., so as to see if the variation was greater at the end of a series than at the beginning. The degree of uncertainty is then the mean variation between the successive means.

A plan almost the same as this has been used; a certain number of facts being recorded, the sum is divided into two, three, or more parts, and it is then seen whether the results drawn from the lesser groups agree with that drawn from the larger group and with each other. If there is any great difference of results, the numbers of the lesser groups are not sufficient. In the instance given above, the mean of the ten years is 22.9; the mean of the first three years is 22; of the second three years is 22.33; of the third three years is 24. The term of three years is therefore far too short to allow a safe conclusion to be drawn. The mean of five years again is 23, and of eight years is 22.8, numbers which are much nearer each other and the mean of the whole ten years.

The application of averages when obtained is of great importance, but there is one usual error. The results obtained from an average (that is, from the mean result obtained from a number of units, not one of which perhaps is the same as the mean result, but either above or below it) can never be applied to a particular case. On either side the average there is always, as before shown, a range the value of which may be obtained by Poisson's rule, or by the determination of the mean error, and the particular case may be at either end of the range. The use of the average is to apply it to an aggregate of facts. Then, supposing it to be founded on a sufficient number of cases, it will approximate proportionately to exactitude.

6. In addition to averages, it is always desirable to note extreme values, that is, the two ends of the scale of which the average is the middle. To use Dr. Guy's pointed expression, "averages are numerical expressions of probabilities; extreme values are expressions of possibilities."[1] In taking too great note of mean quantities, we may forget how great a range there may be above and below them, and it is by reminding us constantly of this that Poisson's rule and the rule for *mean error* are so useful.[2]

7. Statistical results are now frequently expressed by graphic representations, a certain space drawn to scale representing a number. The most simple plan is that of intersecting horizontal and vertical lines.

Two lines, one horizontal (axis of the *abscissæ*), and the other vertical (axis of the *ordinates*), form two sides of a square, and are then divided into segments, drawn to scale—vertical and horizontal lines are then let fall on the points marked; the axis of the ordinates representing, for example, a certain time, and the axis of the abscissæ representing the number of events occurring at any time. A line drawn through the points of intersection of these two quantities forms a graphic representation of their relation to each other, and the surface thus cut can be also measured and expressed in area if required, or the space can be plotted out in various ways, in columns, pyramids, etc. In the same way circles cutting radii at distances from the centre drawn to scale are very useful; the circles

[1] Cyclopædia of Anatomy and Physiology, art. "Statistics."

[2] In a good (that is a trustworthy) series, the extremes on the two sides of the mean will balance each other, the numbers being distributed according to the coefficients of a binomial, whose exponent is the number of possible events in the series (see Quetelet, On Probabilities; Airy, On the Theory of Errors of Observation; Merriman, Theory of Least Squares; F. de Chaumont, Lectures on State Medicine). See table in Appendix E.

marking time (in the example chosen), and the radii events, or the reverse. Such graphic representations are most useful, and allow the mind to seize more easily than by rows of figures the connection between two conditions and events.

Generally speaking, it may be said that the amounts of sickness and mortality in different bodies of men or in the same body of men at successive periods, show such wide variations, that the mean error is always very great, and it requires a very large number of cases, and an extended period, to deduce a probable true mean. For this reason it is necessary to be cautious in apportioning blame or credit to persons, or to special modes of treatment, unless the numbers are very large and accordant. The circumstances influencing the result are, in fact, very numerous, and the proper estimation of a numerical result is only possible when it is considered in reference to the circumstances under which it occurs.

The most important statistical inquiries applied to health are—

1. *Births to Population.*—To obtain all these elementary facts, an accurate census and proper registration are required. It is only within recent years that the most civilized nations have commenced these inquiries.

2. *Relative Number of Live and Still-born, of Premature and full-Grown Children.*

3. *Number of Children Dying in the First Year, with Sub-Groups of Sex and Months.*—There are two great periods of mortality in the first year, viz., in the first week, and at the time of weaning, about the seventh month.

4. *Amount of Sickness to Population.*

(*a*) Number constantly sick, grouped according to sex, age, occupation, and diseases.

(*b*) Average duration of sickness, etc.

5. *Amount of Yearly Mortality in a Population, or Deaths to Population.*—The deaths are generally expressed as so many deaths to 1,000 or 10,000 living; but the deaths can be calculated in relation not only to the number living at the end of the time, but to that number *plus* a certain addition to be made on account of those persons who lived during part of the time, but died before its close. But the difference is not material. Grouped according to sex, age, etc.

6. *Mean Age at Death of a Population is the Sum of the Ages at Death divided by the Deaths.*—The mean age at death expresses, of course, the expectation of life at birth, or the mean lifetime. It is no very good test of the health of a people, as a great infant mortality may reduce the age, though the health of the adults may be extremely good. The mean age of death in England is about 40 years. Farr has shown that it is nearly equivalent to the reciprocal of the death-rate *minus* one-third of the difference between the reciprocal of the death-rate and that of the birth-rate; or two-thirds the reciprocal of death-rate *plus* one-third that of the birth-rate.[1]

7. *Mean Duration of Life* (*vie moyenne*).—This is the expectation of life at birth; at any other age than birth, it is the expectation of life at that age (as taken from a life-table) added to the age. It is no good test of sanitary condition or health.

8. *Probable Duration of Life* (*vie probable;* probable lifetime) is the age

[1] Suppose the death-rate to be 1 in 46, and the birth-rate 1 in 29 (about the existing rates in England), we have $\frac{46 \times 2}{3} = 30.7 + \frac{29}{3} = 9.7 = 40.4 =$ mean age at death in England.

at which a given number of children born into the world at the same time will be reduced one-half.

9. *Expectation of Life, or Mean Future or After Lifetime.*—This is the true test of the health of a people. It is the average length of time a person of any age may be expected to live; and in order to construct it, we must know the number of the living, their ages, the number of deaths and the ages, and the other changes in the population caused by births, emigration, immigration, etc. It does not, of course, follow that any particular person will live the time given in such a table; he may die before or after the period, but taking a large number of cases, the average is then found to apply. Life-tables show at a glance the expectation of life at any age.

England.[1]

Age.	Males.	Females.	Age.	Males.	Females.	Age.	Males.	Females.
0	39.91	41.85	10	47.05	47.67	70	8.45	9.02
1	46.65	47.31	20	39.48	40.29	80	4.93	5.26
2	48.83	49.40	30	32.76	33.81	90	2.84	3.01
3	49.61	50.20	40	26.06	27.34	95	2.17	2.29
4	49.81	50.43	50	19.54	20.75	100	1.68	1.76
5	49.71	50.33	60	13.53	14.34			

After the first year the chances of living increase up to the fourth year; the fifth year is nearly as good, and then the chances of life lessen, but at first slowly, and then more rapidly; from 5 to 40 years of age the expectation of life lessens in the ratio of from $2\frac{1}{2}$ to $3\frac{1}{2}$ or $3\frac{3}{4}$ years for each quinquennial period.

SECTION II.

ARMY STATISTICS.[2]

At the close of the Peninsular war in 1814, Sir James M'Grigor commenced the collection of the statistics of disease and mortality in the English army, and during the course of the next twenty years a great amount of valuable evidence was accumulated. In 1835 Dr. Henry Marshall (Deputy Inspector-General of Hospitals, and one of the most philosophical surgeons who have ever served in the English army) commenced to put these returns into shape, and the late Major-General Sir Alexander Tulloch, K.C.B. (at that time a lieutenant in the 45th Regiment, employed in the War Office), was associated with him. In the following year, on the retirement of Dr. Marshall, Dr. Balfour, formerly head of the Statistical Branch of the Army Medical Department, was appointed as his successor, and in conjunction with Sir A. Tulloch, brought out the series of reports on the health of the army which have had such influence, not merely on the causes of the sickness and mortality among soldiers, but indirectly on those of the civil population also. In 1838–41, reports were issued of the following stations:—United Kingdom, Mediterranean, and British America, West Indies, Western Africa, St. Helena, Cape, Mauritius, Ceylon, and Tenasserim.

[1] Abridged from Dr. Farr's Life Tables. Some interesting information will be found in Statistics of Families, by C. Ansell, jun., 1874.

[2] This short summary of the history of the Army Statistical Reports is chiefly taken from Dr. Balfour's account, in the Army Medical Report for 1860, p. 131.

These returns included the year 1817–1836. In 1853 another report, containing the stations of the troops in the United Kingdom, Mediterranean, and British America, including the years 1836–1846, was prepared by the same gentlemen.

In these reports, in addition to the statistical analysis, short but most graphic and comprehensive topographical and climatic accounts of the different stations were given.

The effect of these several reports, and especially of the earlier issues, was to direct the attention of the Government, both to the fact of an enormous sickness and mortality, and to its causes, and then commenced the gradual series of improvements which at a later period were urged on by Lord Herbert with so much energy.

The Russian war of 1854–1855 prevented any further publication until 1859, when yearly reports were commenced by Dr. Balfour, and have been regularly issued since. In the report for 1860 Dr. Balfour gave a summary of the earlier and later mortality of the different stations before and after 1837, which showed a remarkable difference in favor of the later periods as regards both sickness and mortality.

Sub-Section I.

With respect to soldiers, *in time of peace*, the statistical evidence is required to show the amount of benefit the State receives from its soldiers, and the amount of loss it suffers yearly from disease. Tables should therefore show—

1. The amount of loss of strength a definite number of men in each arm of the service suffers in a year—

(*a*) By deaths, or, in other words, the mortality to strength.

(*b*) By invaliding from disease,[1] for if this is not regarded, different systems and modes of invaliding may entirely vitiate any conclusions drawn from the mortality.

The groups thus formed must be again subdivided, so as to show—

(*a*) The *causes* of death or invaliding.

(*b*) The *ages* of those who die or who are invalided.

(*c*) Their *length* of service. It is of great importance to determine the influence of service in every year, and these groups should be again divided by ages.

2. The *loss of effective service* a definite number of men—say, 1,000 men in each arm—suffers during a year. This is best expressed as follows:—

(*a*) *The total number of cases of disease* in a year, *i.e.*, the number of admissions to hospital per annum. It must be understood that this does not express the number of men admitted, as one man may be admitted two, three, or even ten times with the same disease; each admission counts as a fresh case. It is important to have another table showing the number of men admitted for different diseases, or, in other words, the number of cases of readmission for the same disease. The actual number of *cases treated* in a period may be obtained from the mean of the admissions and discharges.

(*b*) The *number constantly sick* on an average. This is often called the

[1] Loss by purchase of discharge, expiration of term of service, imprisonments, and dismissals from the army, must also be put under separate headings; but the medical officer has nothing to do with this point, except to see that such cases are not confounded with invaliding from disease.

sick population, and is obtained most easily in army hospitals by dividing the number of diets issued in a year by 365, or adding all the "remaining" on the daily or weekly states together, and dividing by 365 or 52, as the case may be.

(*c*) The total number of days lost in a year to the service by illness by each 1,000 men, and of the number of days per head. The number of the sick population (that is, the number constantly sick out of, say 1,000 men) multiplied by 365 and divided by 1,000, or by the number furnishing the sick, whatever that may be, gives these facts.

(*d*) The mortality in relation to sickness.

The group constituted by the sick must then be subdivided by diseases, and lesser groups must be made by distributing the causes of sickness and deaths under ages and length of service.

There are a few points which require attention. The amount of sickness and mortality is calculated on the mean strength, that is, the number of men of a regiment present at a certain station on the muster days divided by the number of muster days. But it must be understood that this includes the sick men in hospital as well as the healthy men, and therefore does not perfectly express the amount of disease among the healthy men. Also sometimes the muster rolls of a regiment include men on detachment at some distance, whose sickness is not attributable to the headquarter station. The French, in their Army Statistical Returns, make two headings, one of "mean strength" (*effectif moyen*), and the other of "present" (*présents*), the men in hospital not being included in the latter. Moreover, in the French army, nearly one-sixth are always absent on leave; and the deaths of those on leave are included among the army deaths, but the sickness is not so. Consequently, sickness has to be calculated on the number not on leave; deaths, on the total strength. In the French army officers are included with the men; in the English, separate returns are made.

It is often difficult to get the mean strength if there are many changes of troops, and instances of erroneous calculations from this cause are not uncommon.[1]

In calculating also the effect of age and length of service upon disease and mortality, it is necessary to know not only the ages and length of service of the sick men, but of the healthy men also, and to calculate out the

[1] The following is one which Dr. Balfour has given. It will be seen that an unhealthy station (Masulipatam) in India is credited with a much greater degree of health than it really was entitled to, and the annexed extract from Dr. Balfour's paper (Edin. Med. and Surg. Jour., No. 172) shows clearly how the mistake arose:—

"The [Madras] Medical Board, in submitting to Government the table from which these figures are computed, stated that the ratio of mortality among all the European regiments in the Presidency, from January, 1813, to December, 1819, was 5.690 per cent.; whilst that of the regiments at Masulipatam, from 1813 to 1832 inclusive, was 5.100 per cent. They then add—'The rate of mortality having been somewhat lower than throughout the rest of the Presidency for such a period, gives reason to conclude that the station cannot be considered under ordinary circumstances as unhealthy.' Now, the Board appears to have arrived at this conclusion from an error in the mode of calculating the ratio. In several of the years between 1813 and 1832 the regiments were quartered at Masulipatam during part of the year only. It must be obvious to any one conversant with the principles of statistics, that in such a case a proportion of the annual strength only should be taken corresponding with the period for which the regiment was quartered there. Thus, if the period was nine months, the sickness and mortality should be calculated on three-fourths of the strength; if eight months, on two-thirds, and so forth. The Board, however, have made the calculation in every instance on the average annual strength without any such deduction. Had the necessary correction been made, the deaths from 1813 to 1832 would have been found to average 6.394 per cent. annually, instead of 5.100 as above stated."

proportion of the sick to the healthy at that particular age or length of service, otherwise very erroneous conclusions might be drawn. For example, it might appear that sick men under twenty years of age were very numerous in proportion to other years, but in a very young army the greater number of the force might be of this age. Care is necessary in all these points to arrive at correct conclusions.

Sub-Section II.—Statistics in War.

In time of war the statistics must be slightly altered in form, though the same in principle. The object is to show as completely as possible to the General in command what amount of loss his army is suffering at the moment, and to what extent it may be expected to suffer, and also what are the causes of such sickness.

The sickness here must not only be calculated on the mean strength (which will include the men in hospital), but also on the healthy men, or those actually under arms and effective. If the sick are counted in the strength, the sickness of the army may be much understated. What a General wants to know with regard to sickness will be these points—

1. How many men am I losing daily from the rank and file actually serving with the colors?
2. How many are replaced by discharge from hospital?
3. What is the balance, gain or loss?
4. If my effective force loses daily, when this balance is struck, such a percentage, what will be its loss of strength in a week, in four weeks, in six weeks? etc.
5. What are the causes, *i.e.*, what are the diseases which are causing this sickness, and how are they affected by special circumstances of age, particular service or arms, or other causes?

The mortality in war should be calculated on the mean strength, that is, on the total number of healthy and sick, and also on the sick alone, so as to represent both the loss of the army and the fatality of the sickness.

Book II.

THE SERVICE OF THE SOLDIER.[1]

It is now necessary to consider a little more particularly the nature of the service of the soldier, and the influence it has on him. A recruit entering the army from civil life comes under new conditions, which will require to be shortly enumerated.

CHAPTER I.

THE RECRUIT.

In the English army, young men are now enlisted at nineteen years of age,[2] unless they are intended for drummers. They must be of a certain height, which is fixed by regulation from time to time, according to the particular arm, and to the demands of the service. There must also be a special girth of the chest, which is in proportion to the age and height.

In time of war, the measurements are reduced according to the demand for men; and even in time of peace, the necessary height of the infantry recruit is varied. At present it is 64 inches.[3] Before the enlistment is completed, the recruit is examined by a medical officer, and then by the surgeon-major of the recruiting district, according to a scheme laid down in the "Medical Regulations."[4] The scheme is a very good one, and aims at investigating, as far as can be done, the mental condition; the senses; the general formation of the body, and especially of the chest; the condition of the joints; the state of the feet; the absence of hernia, varicocele, piles, etc.; and the condition or physical examination of the heart, lungs, and abdominal organs generally.[5] A certain minimum girth of chest according to the height is required.[6]

[1] Medical officers entering the army will find a great deal of useful sanitary information and details of duty bearing on health in Sir Garnet Wolseley's Soldiers' Pocket Book for Field Service.

[2] In reality they sometimes enlist under this age.

[3] General Order, No. 81, July, 1881.

[4] For a full account of the system of recruiting, the mode of examination, and much useful information on disabilities, see a paper by Dr. Crawford, in the Army Medical Report for 1862: Blue Book, 1864. See Medical Regulations (1878), part 4, section ii.

[5] As the Medical Regulations are in the hands of all medical officers, it is unnecessary to go into more detail on this point. Professor Longmore uses in the Army Medical School a set form of examination (Instructions on the Examination of Recruits, Southampton, 1862), which renders it almost impossible that any point should be overlooked.

[6] At present, 34 inches for 64 to 70 in height; 35 inches if above 70 in height.

After joining his regiment he is again examined, and may be rejected if any defect is discovered. Rejections may take place then either at the primary or secondary inspection.

The trades of the men furnishing recruits vary greatly from year to year.

The total number of rejections, either at once or after re-examination by a second medical officer, on various grounds, of men brought by the recruiting sergeant to the medical officer, varies somewhat from year to year.

About two-fifths of the rejections arise from causes connected with general bad health or feeble constitution, and one-fifth from causes affecting the marching powers of the men (Balfour).

In the French army, the height was fixed in 1860 at 69 inches (1.76 metre) for the carabiniers, and 61½ inches (1.56 metre) for the infantry of the line.

In 1872 the maximum for the cuirassiers was reduced to 1m.70 (67 inches) without any fixed maximum.

In 1868 the maximum for the line was reduced to 1m.55 (61 inches), and still further, in 1872, to 1m.54 (60½ inches).[1]

The rejections in the French conscription include men rejected for insufficient height, as well as reasons of health.[2]

After the recruit has been enlisted and approved, he joins his depôt or his regiment; receives his kit, which he subsequently in part keeps up at his own cost; and is put on the soldier's rations. He enters at once on his drill, which occupies from 3½ to 4½ hours daily. Wherever gymnasia are established, he goes through a two-months' course of gymnastic training for one hour every day. He then goes to rifle drill, which lasts about six weeks, and then joins the ranks. After the rifle drill, he has another month's gymnastic training, and is then supposed to be a finished soldier.

Such being the system, it will be desirable to consider certain points.

1. *The Age of the Recruit.*—Strong opinions have been expressed by Ballingall (English army), Lévy (French army), Hammond (American army), and other army surgeons, that the age of 17 or 18 is too low—that the youngest recruit should be 20 or 21 years of age.

This opinion is based both on actual experience of the effect produced on boys of 17 to 20 when exposed to the hardships of war, or even to heavy duty in time of peace, and on a physiological consideration of the extreme immaturity of the body at 18 years of age.

With regard to the first point, there is no doubt that to send young lads of 18 to 20 into the field, is not only a lamentable waste of material, but is positive cruelty. At that age such soldiers, as Napoleon said, merely strew the roadside and fill the hospitals. The most effective armies have been those in which the youngest soldiers have been 22 years of age.

With regard to the second, it is also certain that at 18 the muscles and bones are very immature, and, in fact, it is not till 25 years of age, or even later, that epiphyses of the bones have united, and that the muscles have attained their full growth.[3]

The epiphyses of the transverse and spinous processes of the vertebræ hardly commence to ossify before 16 years of age, and it is not till after 20 years that the two thin circular plates form on the body of the vertebræ. The whole process is not completed till close on the 30th year. The con-

[1] Morache, Traité d'Hygiène Militaire, 1874.
[2] Sistach, Recueil de Mém. Mil., November, 1861, p. 353.
[3] See Aitken's Growth of the Recruit and Young Soldier, 1862.

solidation of the sacrum only commences at the 18th year, and is completed from the 25th to the 30th year. The fourth and third bones of the sternum are only united between the 20th and 25th years, and the second is not united to the third bone before the 35th year. The epiphysis of the ribs commence to grow betweeen the 16th and the 20th years, and are completed by the 25th year. The epiphysis of the scapula join between the ages of 22 and 25. The epiphysis of the clavicle begins to form between the 18th and 20th years. The internal condyle of the humerus unites at 18, but the upper epiphysis does not join till the 20th year. The epiphysis of the radius and ulna, the femur, the tibia, and fibula, are all unjoined at 18 years, and are not completely joined till 25 years. The epiphysis of the pelvic bones (viz., crest of ilium, spine, and tuberosity of the ischium) begin to form at puberty, and are completed by the 25th year.[1]

That the muscles are equally immature is just as certain; they grow in size and strength in proportion to the bones.

These facts show how wrong it is to expect any great and long-continued exercise of energy from men so young as 18 and 20, and what will be the inevitable consequences of taxing them beyond their strength.

Are we, then, to conclude that the soldier should not be enlisted before 20?

If the State will recognize the immaturity of the recruit of 19 years of age, and will proportion his training and his work to his growth, and will abstain from considering him fit for the heavy duties of peace and for the emergencies of war till he is at least 20 years of age, then it would seem that there is not only no loss, but a great gain, by enlisting men early. At that most critical period of life the recruits can be brought under judicious training, can have precisely the amount of exercise and the kind of diet best fitted for them, and thus in two years be more fully developed, and be made more efficient, than if they had been left in civil life.

2. *The Height and Weight of the Recruit.*—The desire of almost all military officers is to get tall men. The most favored regiments, especially the cavalry, get the tallest men. It has been recommended both that shorter men should be generally taken, and that the infantry should have the tallest men. The last point is one for military men to determine, and must be decided by considerations of the respective modes of action of cavalry and infantry.

The first point is entirely physiological, and opens a difficult question.

What is the height, at 19 years of age, which is attended with the greatest amount of health, strength, and endurance, or is it possible to fix such a standard?

Tables of average height and weight have been compiled by Quetelet, and much used, and lately somewhat similar tables have been framed by Danson, Boyd, and Liharzik.[2]

With regard to all of these it may be said that the observations (however numerous) are yet too few for such a large question, and that the influence of race has been too little regarded.

Boyd gives the height at 18 years at 60.4 inches, and at 25 years at 67 inches, and Liharzik at the same ages gives 64.17 and 68.9 inches. The English Army Returns (1860–67) give the heights of the recruits, but it

[1] See Aitken's Growth of the Recruit, p. 37, and Quain's Anatomy, for still fuller details.

[2] Liharzik's numbers profess to be based on a law induced from great numbers of measurements in different animals.

must be understood that we cannot deduce the mean height of the population from these figures, as the shorter men are not taken as recruits.

Although the numbers are not very accordant, we may perhaps assume that at 19 the average height will be something near 65 inches, and the average weight 125 lb.

The best rule to guide us is that given by Dr. Aitken, viz., to take into consideration the three points of age, height, and weight, and if either in weight or height, or both together, there is any great divergence from the mean, then something wrong will probably be found. But as long as weight and height are in accord, the taller and heavier the man the better, as a rule. The weight in pounds ought to be about *twice* the height in inches.

One point is, however, quite clear. When the height is much below the mean, the bodily development generally is bad. Hammond states that in the American war, men of less than 5 feet broke down by a few weeks' campaigning, while men of 5 feet stood the work well. Probably 63 inches at 19 years of age, and 120 lb weight, should be a minimum, even in times of the greatest pressure. So also a very great height at 19 years of age is objectionable, and anything over 68 inches at that age should be looked on with great suspicion. As a rule, also, adult men of middle size (67 to 69 inches) appear to bear hard work better than taller men.[1]

3. *The Physical Training of the Recruit.*—A great improvement has been introduced by the order that each recruit shall have three months' gymnastic training. If properly done, this will have a most beneficial effect. The medical officer will have power to continue this if necessary, and care should be taken to use this power.

4. *The Mental Training.*—Since the introduction of rifle practice, the trade of a soldier has become much more interesting to him; he is now taught scientifically how to manage his arm, and learns to take interest in his shooting. It would be most desirable to give him some knowledge of the Military Art, and of the object of the manœuvres he goes through. A military literature fitted for the private soldier is still wanting. It is also very important to train him for the field, and to teach him to perform for himself all the offices which in time of war he will have to do—not merely trench work, but hutting, cooking, washing and mending his clothes, as in time of war. It is too late, at the commencement of a campaign, to begin these necessary parts of a soldier's education; they should form part of his training as a recruit; and if he is excused guard and other duties during his first year, there would be ample time.

Great attention is now being directed to the importance of soldiers keeping up their trades, or learning some trade if they have none. Such a system occupies men, makes them contented, keeps them from dissipation, and opens a career for them when they leave the army. Instead of interfering with their military training, it can be made to subserve it, and possibly might be found to be advantageous to the State, even in a pecuniary point of view. The recruit then would have to keep up or learn his trade.

5. *The Moral Training.*—The recruit, on entering the army, is brought under moral influences of a strong kind. A discipline always rigorous,

[1] For some useful information on these points, see Morache, op. cit., Roth and Lex, op. cit., and Auguste Jansen, Études sur la taille, le périmètre de la poitrine et le poids des recrues, extrait des Archives Médicales Belges, 1877; also Étude d'Anthropométrie Médicale au point de vue de l'Aptitude au service militaire, by the same author, Bruxelles, 1882.

and sometimes severe, produces often a ready obedience and a submission of character, and, when not carried too far, greatly improves him. At the same time, independence is preserved by the knowledge which the soldier has of his rights and privileges, and the result is a manly, conscientious, and fine character. But occasionally, a too sensitive nature on the part of the recruit, or a discipline too harsh or capricious on the part of his officers, produces very different results, and the soldier becomes cunning, artful, and false, or morose and malicious. The two characters are often seen well marked in old soldiers, and no contrast can be greater than between the two. A heavy responsibility rests, then, with the officers of the army who have power thus to influence, for good or evil, natures like their own.

The influence of companionship is also brought to bear on the recruit, and is fraught with both good and evil. The latter probably predominates, though there are many excellent, high-minded, and religious men in the army. Indeed, in some regiments the proportion of steady religious men is perhaps beyond the number in the analogous class in civil life. But if the influences be for bad, the recruit soon learns some questionable habits and some vices.

Thus he almost invariably learns to smoke, if he has not acquired this habit before. It is indeed remarkable what a habit smoking tobacco is in every army of Europe ; it seems to have become a necessity with the men, and arises probably from the amount of spare time the soldier has, which he does not know what to do with. A recruit, on joining, finds all his comrades smoking, and is driven into the habit.

The discussion on the effects of tobacco does not seem to have led to any clear conclusions. The immoderate use brings many evils, to digestion and circulation especially. But no great evils appear to result from the *moderate* use, though no good can be traced to it. In moderation it has not been proved to lessen appetite, to encourage drinking, or to destroy procreative power. But, on the other hand, it probably lessens bodily, and perhaps even mental activity. It is certainly remarkable how uniformly the best trainers prohibit its use, and men of the highest physical vigor are seldom great, and often are not even moderate smokers. As it is of no use, and indeed injurious, by bringing men under the thraldom of a habit, it seems very desirable to discourage it. But in the army it seems useless to fight against this custom, nor is it indeed one which is sufficiently injurious to be seriously combated, except for one reason. In time of war, the soldier often cannot obtain tobacco, and he then suffers seriously from the deprivation. The soldier should have no habits which he may be compelled to lay aside, and which it would pain him to omit.

A much more serious matter is the vice of drinking, which many recruits are almost forced into, in spite of themselves. The discipline of the army represses much open drunkenness, though there is enough of this, but it cannot prevent, it even aids, covert drinking up to the very edge of the law. Formerly, a most lamentable canteen custom made almost every man a drunkard, and a young boy just enlisted soon learned to take his morning dram, a habit, which, in civil life, would mark only the matured drunkard. Now, happily, spirits are not sold in the canteens, and no regulation thrusts raw spirits down a man's throat. Drinking is, however, still the worst vice in the army, and that which strikes most of all at the efficiency of the soldier. Great efforts have been, however, made by the military authorities to check this vice, and there is little doubt that the army is gradually becoming more temperate.

Another vice is almost as certainly contracted as smoking by the recruit. Probably, before enlistment, he has led no very pure life, but when he enters the army, he is almost sure to find his moral tone higher than that of some of his new associates. A regiment, in fact, is composed of young men with few scruples and small restraints. Prevented from marriage, and often tempted by low prostitutes, it is no wonder if, to the extent of his means, the soldier indulges in promiscuous sexual intercourse. He does this, in fact, to excess, and the young recruit is led at once into similar habits. That many recruits are most seriously injured by this habit, even if they neither contract syphilis nor gonorrhœa, is certain.

It has also been supposed that solitary vice is particularly rife in armies. There does not seem to be any evidence on this point.

6. *The Amount of Sickness and Mortality suffered by the Recruit during the First Six Months and Year of Service.*—This is an extremely important matter, but at present we are not able to answer the question for the English army.

In the French army,[1] the amount of sickness among soldiers under one year of service is more than one-third greater than among the army generally; this is partly caused by slight injuries, though not solely, for the admissions to hospital are nearly one-fourth more among them than in the army at large.

[1] Statistique Médicale de l'Armée.

CHAPTER II.

THE CONDITIONS UNDER WHICH THE SOLDIER IS PLACED.

These conditions are extremely various, as the soldier serves in so many stations, but the chief points common to all can be passed in review.

The water and air supplies have been already sufficiently noticed, and the conditions now to be noticed under which the soldier is placed are *barracks*, *huts*, *tents*, and *encampments*; the *food*, *clothing*, and *work*.

SECTION I.

BARRACKS.

Barracks have been in our army, and in many armies of Europe still are, a fertile source of illness and loss of service. At all times the greatest care is necessary to counteract the injurious effects of compressing a number of persons into a restricted space. In the case of soldiers, the compression has been extreme; but the counteracting care has been wanting. It is not more than sixty years since, in the West Indies, the men slept in hammocks touching each other, only 23 inches of lateral space being allowed for each man. At the same time, in England, the men slept in beds with two tiers, like the berths in a ship; and not unfrequently, each bed held four men. When it is added, that neither in the West Indies, nor in the home service, was such a thing as an opening for ventilation ever thought of, the state of the air can be imagined.

The means of removal of excreta were, even in our own days, of the rudest description, both at home and in many colonies; and from this cause alone there is no doubt that the great military nations have suffered a loss of men which, if expressed in money, would have been sufficient to rebuild and purify every barrack they possess.[1]

[1] It is a most remarkable circumstance, that the two diseases which, in the French, Prussian, Hanoverian, and Belgian armies, and probably in the Austrian, and, till lately, in our own army, caused the largest share of mortality, were a destructive lung disease, termed *phthisis* in the returns, and *typhoid fever*.

The production of disorganizing lung disease (though occurring in several other ways) is intimately connected with the constant breathing of an atmosphere vitiated by respiration; and typhoid fever is as closely related with bad drainage. Both diseases are therefore diseases of habitations, and show, in the case of the soldier (who is not subjected to other causes of phthisis, such as inaction, constrained position, and inhalation of dust, etc.), that the air of his dwelling is foul. In hot climates the same rule holds good. Is it not a remarkable fact, that in the West Indies, those islands of paradise, where no cold inclement wind ever vexes the tender lungs, there was, forty or fifty years ago, an extraordinary mortality from consumption, and from a continued fever, which in all probability was typhoid? Yet who can wonder, when we find, in the

Sub-Section I.—Barracks on Home Service.[1]

The imperfection of the English barracks was owing to two causes—first, a great disregard or ignorance of the laws of health; and, secondly, an indisposition on the part of Parliament to vote sums of money for a standing army. At the close of the last, and at the commencement of the present century, the Whig party especially opposed every grant which Mr. Pitt brought forward for this purpose.[2] After the great war, the exhaustion of the nation prevented anything being done, and in spite of the representations of many military men, comparatively little change occurred till the Crimean war. In 1855, a committee,[3] of which Lord Monck was chairman, was appointed by the War Office to consider this subject, and presented a most excellent Report on Barracks, the suggestions of which have been since gradually carried out. Immediately after this, a Barrack Improvement Commission[4] was organized, and in 1861 this Commission published a Blue Book, which not only contained plans and descriptions of the existing barracks and hospitals, but laid down rules for their construction, ventilation, and sewerage, for future guidance. It is difficult to speak too strongly of the excellence of this Report, and if its rules are attended to, there can be no doubt the British army will, as far as habitations are concerned, be lodged in healthier dwellings than almost any class of the community.[5] Reference must be made to this report for a fuller account of the older barracks and hospitals than can be given here.[6]

Windward and Leeward command, the very best barrack, in 1827, gave only this amount of accommodation: the men slept in hammocks touching each other; the average space allowed to each man measured only 23 inches in breadth; and the total cubic space per head, in this, the best barrack in a tropical climate, was only 250 cubic feet. The air was, of course, putrid in the highest degree.

So also in India, the best writer on the means of preserving the health of troops in India (Dr. Chevers) did not hesitate to assert that faulty barracks were, though not the only, yet a great cause of a mortality which, in a term of years, had been at least fourfold more than at home. Phthisis and typhoid fever hold a subordinate place (though it is not unlikely that their frequency was underrated); but other diseases appear, which are in part connected with faulty barrack arrangements, such as dysentery and cholera.

In India, as in England, no expense has of late years been spared; but yet the fact remains, that the very habitations erected for their shelter and comfort proved in many cases to the soldiers a source of suffering and death.

[1] Army medical officers are referred to an admirable paper by Surgeon-General Dr. Massy, C.B., on the Construction and Ventilation of Barracks and Hospitals (Army Med. Dep. Report, vol. vi., p. 229).

[2] On looking through the Annual Register, it will be found that Fox, as well as his followers, spoke strongly against the grant of sums of money for improving barracks. Their motives were good, and their jealousy of a standing army justified by what had gone before, but the result has been most unfortunate for the soldier.

[3] Report of the Official Committee on Barrack Accommodation for the Army, Blue Book, 1855.

[4] Mr. Sydney Herbert, Drs. Sutherland and Burrell, and Captain Galton, were the first Barrack and Hospital Improvement Commissioners. Lord Herbert did not sign the first Report, as he became Minister of War. Dr. Burrell retired. The remaining Commissioners (Dr. Sutherland and Captain Galton) subsequently published the Report on the Mediterranean and other Barracks.

[5] General Report of the Commission appointed for Improving the Sanitary Condition of Barracks and Hospitals, 1861.

[6] For the duties of medical officers with respect to barracks, see Queen's Regulations, 1881, Section 15; and the Army Medical Regulations, 1878.

Infantry Barracks.

Block Plan.—Formerly a number of men, even a whole regiment, were aggregated in one large house, and this was often built in the form of a square (a plan originated by Vauban), the quarters for the officers forming one side, on account of the ease of surveillance. Many officers still prefer this form. But it is always objectionable to have an inclosed mass of air, and if it is adopted the angles should be left open, as recommended by Robert Jackson. The Barrack Improvement Commissioners have very justly recommended that there shall be division of the men among numerous detached buildings; and instead of the square, that the separate buildings shall be arranged in lines, each building being so placed as to impede as little as possible the movement of air on the other buildings, and the incidence of the sun's rays.

In arranging the lines, the axis of the buildings should be if possible north and south, so as to allow the sun's rays to fall on both sides. One building should in no case obstruct air and light from another, and each building must be at a sufficient distance from the adjoining house, and this distance should not be less than its own height, and if possible more.

Parts of a Barrack.—1. The barrack room, with non-commissioned officers' rooms screened off. 2. Quarters of the married privates—seven to each company. (With the short service system this will probably be modified.) 3. Quarters of the staff-sergeants and sergeants' mess. 4. Quarters of the officers. 5. Kitchens. 6. Ablution rooms. 7. Latrines and urinals. 8. Orderly-room; guard-room. 9. Cells. 10. Tailors' shop and armory; commissariat stores; canteen. 11. Reading-room (in many barracks); schools; magazine.

It is unnecessary to describe all these buildings.

The old barracks are of all conceivable forms and kinds of construction, for details of which see the Commissioners' Report.

When new barracks are built, the plans of the Commission will be followed.

(*a*) *Barrack Rooms.*—The size and shape of the barrack room will decide the kind of buildings. The Barrack Committee of 1855 recommended that each room should accommodate twelve men, or one squad, as this is most comfortable for the men; but small rooms of this size are more difficult to arrange, and it is now considered best to put twenty-four, or one section, in each room.

The Barrack Improvement Commissioners' recommendations may be condensed as follows:—

The rooms are directed to be narrow, with only two rows of beds, and with opposite windows—one window to every two beds. As each man is allowed 600 cubic feet of space, and as it is strongly recommended that no room shall be lower than 12 feet, the size of a room for 24 men will be—length 60 feet, breadth 20 feet, height 12 feet. This size of room will give 14,400 cubic feet, or (600 × 24) enough for 24 men; but as the men's bodies and furniture take up space, an additional 2 feet has been allowed to the length in some of the new barracks. Assuming the length to be 62 feet, the superficial area for each man will be nearly 52 feet, a little more than 5 feet in the length and 10 in the width of the room. At one end of the room is the door, and a room for the sergeant of the section, which is about 14 feet long, 10 wide, and 12 high. At the other end is a narrow passage leading to an ablution room, one basin being provided for 4 men, and a urinal.

Such is the present arrangement of a single barrack room, and it is difficult to conceive a better plan, unless it might be suggested that an open veranda, never to be made into a corridor, should be placed on the south or west side. It would be a lounging-place for the men. So also a cleaning-room for arms and accoutrements would be a very useful addition.

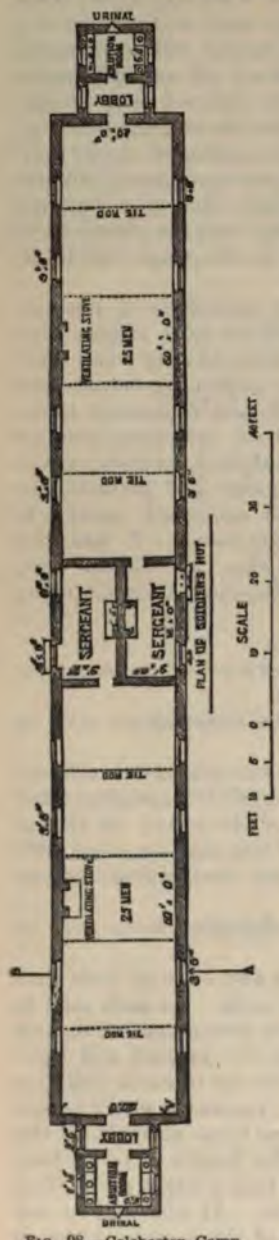


FIG. 98.—Colchester Camp Houses.

The room thus formed may constitute a single hut, but if space is a consideration, two such rooms are directed to be placed in a line, the lavatories being at the free ends. A house of this kind will accommodate half a company. The several houses are separated by an interval of not less than 25 feet. For the sake of economy, however, the houses will in future be frequently made two-storied, so that one house will contain a company in four rooms, and ten will suffice for a regiment.

The three following plans of recently erected barracks show the arrangements which are adopted:—

1st, When there is a single story, as at Colchester, and no staircase is required.

2d, When there are two stories, and a staircase must be introduced, as in the new cavalry barracks at York.

3d, When there are not only staircases, but the barracks must be extended in one long line, including many rooms, and when, therefore, the ablution rooms cannot be put at the ends of the rooms, but must be placed on the landings, as at Chelsea.

If ten houses are thus formed, and arranged so as to insure for each the greatest amount of light and air, the following area will be occupied by these houses alone. Each house (with walls) would measure about 140 feet long and 22 broad, and the space between the houses may be taken at 64 feet, or twice the height of the house. The external houses would, of course, have clear spaces on both sides like the others. The area of occupied and unoccupied space would be very nearly 12 square yards to a man.

But this amount of compression, which would be injurious in a large city, will do no harm in these well-planned and ventilated barracks.

(*b*) *Day-rooms.*—The soldier lives and sleeps in his barrack room; it has long been a desideratum to introduce day-rooms,[1] but at present the expense is too heavy. Still it is very important that the men should take their meals elsewhere than in their barrack room, and in

[1] See Report of Committee (1855), p. iv. The objections to day-rooms are—1st,

some barracks a room is provided close to the kitchen. The addition of a few verandas to the rooms would be less expensive; and if reading-

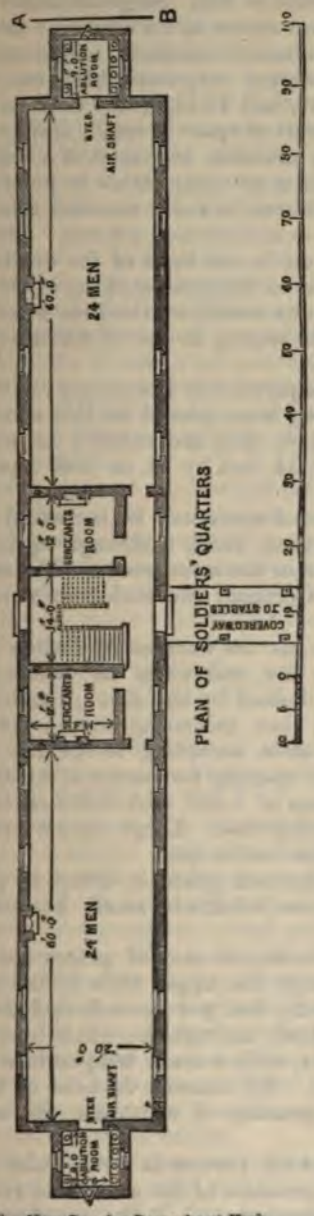


FIG. 99.—New Cavalry Barracks at York.

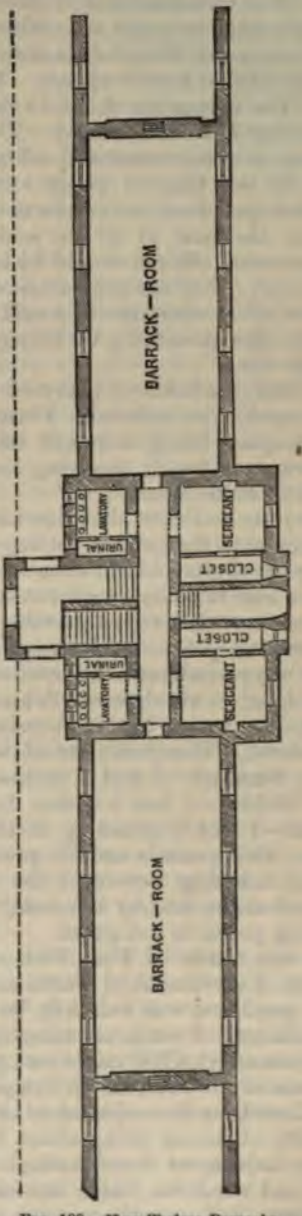


FIG. 100.—New Chelsea Barracks.

More labor to keep clean; 2d, Chance of men being debarred from their barrack room during day; 3d, Chance of day-room being appropriated on emergencies. The Committee, therefore, recommend only dining-rooms for the men, to be arranged near the kitchen, if possible.

rooms were provided, some of the purposes of day-rooms would be obtained.

(*c*) *Non-Commissioned Officers' Rooms.* — The Sergeant-major and Quartermaster-sergeant are entitled to two rooms and a kitchen ; the Paymaster-sergeant, Hospital-sergeant, Schoolmaster-sergeant, and some others, are entitled to two rooms. The company sergeants have one room each. The rooms are about 14 feet by 12, and 10 high, and contain about 1,680 cubic feet when empty. The amount of space is small, and as many of these non-commissioned officers are married, and as it is a matter of justice no less than of policy to make them as comfortable as possible, it is to be hoped that two rooms may be allowed to every married man, and three in the case of all the senior non-commissioned officers. The non-commissioned officers should be looked on in the light of the overlookers of a factory; they are even more essential to the good working of the army than the overlookers are in a mill ; but no married overlookers would ever conceive the possibility of living in two rooms, in one of which cooking must be done.

(*d*) *Married Soldiers' Quarters.*—Seven privates in a company of 100 men are allowed to be married. Formerly they were placed in the men's barracks, a space being screened off, but now they are entitled to separate quarters, each family receiving one room 14 feet by 12, or 168 superficial and 1,680 cubic space.

There is no doubt that this allowance of space will be increased in accordance with the general feeling of the time, which is strongly against the mixing up adults and children of all ages in the same room. The amount of space also is really much too small. Certainly two such rooms ought to be given to each married private.

Warming of Barrack Rooms.—The rooms are warmed by Galton grates in two ways—radiant heat from an open fire, and warm air, which is obtained from an air-chamber behind, and heated by the fire. The external air is led by a pipe to this chamber, and then ascending, enters the room by a louvre. The grates are of various sizes, according to the size of the room. Smallest—1 foot 3 inches of fire opening for rooms of 3,600 cubic feet. Middle—1 foot 5 inches for rooms of 3,600 and 9,800 cubic feet. Largest—1 foot 9 inches up to 12,000 cubic feet. Large rooms have two grates. One grate is usually provided for twelve men.

The radiating power of the small barrack grate is aided by a well-arranged angle, and by a fire-clay back ; as the fire is small, however, the radiating power is not great.

In the wards of Fort Pitt, with the largest size of grates, the mean rapidity of movement of warm air through the upper slits of the louvre, with a good fire, was found to be about 2½ feet per second, and the total cubic amount of warm air entering per hour through the whole louvre was (approximately) 4,600 cubic feet per hour, with a mean temperature of 19° in excess of the external air-temperature. No unusual dryness of the air is produced by the admission of this quantity of warm air, the relative humidity of the air being about 70.

The movement of air through the hot-air louvres is not regular ; open doors and windows, which increase the pressure of the air of the room on the louvre, will sometimes delay the movement, and, if the air-chamber is not very hot, will even reverse it and drive the air down, as the rapidity of movement in those hot-air chambers is never very great ; but in cold weather, when the doors and windows are shut, the action is tolerably regular.

Ventilation of Barrack Rooms.—(See under VENTILATION.)

Ablution Rooms.—Formerly the means for washing were of a very rude kind, but now in the new barracks regular basins with clean water and discharge dirty-water pipes are provided close to every room, in the proportion of one basin to four men. The basins are of slate or iron. In several cases basins on the floor have been provided for feet-washing, and in some instances there are also baths for each regiment. The Barrack Improvement Commissioners recommend one bath to every 100 men. It is understood to be the desire of the Government to provide plunge-baths wherever practicable, and this would not only aid cleanliness, but might be made the means of teaching the men swimming, as suggested by Mr. M'Laren.

If water be scarce, the most economical kind of bath is a shower-bath, so arranged as to permit 80 to 100 men to have a bath at once.

Inspections for cleanliness are made in many regiments. They should be systematically carried on under the direction of good non-commissioned officers; but, if means are provided, soldiers will generally be cleanly.

Kitchens.—Great improvements have been made in cooking by the employment of better ovens and boilers, and especially by making use of steam, as in Warren's cooking stoves. The cost of fuel per head has been greatly reduced.

The opinion of the medical officer will seldom be asked on the question of construction, at any rate on home service. He may, however, be referred to on the question of consumption of fuel, and then he can take as the standard for an ordinary good apparatus ½ lb of fuel per man per diem.

More often, however, he will have to examine the cooking, to which reference is made under the different sections in the chapter on FOOD. The chief points to which attention should be paid, are the temperature, the rapidity of its application, and the ventilation of roasting ovens. Faulty cooking will generally be found to be owing to one or other of these conditions.

Formerly the regimental cooking establishment was badly arranged; men cooked by turns, and for short periods only. Now, cooks are regularly trained at Aldershot.

The other parts of a barrack are—officers' quarters; laundry (in some cases); workshops for tailor, shoemaker, and armorer; orderly-room; guard-room; cells; reading-room (in some cases); chapel and school, which are often in one; magazine; barrack-masters' and quarter-masters' stores for regimental purposes, bread, and meat.

Guard-room.—The guard-room for a regiment of 1,000 strong has a size of about 24 feet by 18; two rooms open into it—one a lock-up for prisoners, the other a room where prisoners are placed who are not put in the lock-up. In many barracks, however, the lock-up is placed near the cells. The guard-room is ventilated like the other rooms, with Sheringham valves, shafts, etc. M'Kinnell's ventilator is well adapted for it. It should be fitted with a drying closet by the side of the fire, to dry the men's clothes when they come in wet off sentry.

Cells.—The cells are ranged on one or both sides of a corridor. They are 10 feet long, 6½ wide, and 9 high (= 605 cubic feet), with one window, 2 feet 9 inches wide by 1 foot 3 inches high, placed at the top of the wall, and guarded by iron bars. A movable iron shutter is sometimes added for security, and to make the cell a dark one if needed. Fresh air is admitted through a grating opening from the corridor, which is warmed. The air enters below, or in some cases above; but the former arrangement is the

best. A foul-air shaft runs from the top of the room. Two cells are provided for every 100 men. A medical officer inspects the cells every day.

Latrines and Urinals.—Formerly, urine tubs were brought into barrack rooms every night; and indeed this is still done in some barracks. The tubs are charred inside, and emptied every morning and filled with water during the day. In all new barracks urinals are introduced; they are placed at the end of the passage beyond the ablution room. It is found by the men that this is inconvenient; the passage is often wet and cold. If the urinal is full of water, it splashes; it might be well to put the overflow-pipe a little lower down. It has been recommended to put a small pipe and stopcock a few inches above the urinal, so that the men may cleanse themselves, and in this way possibly lessen the chances of syphilitic infection.

Cesspits are now discontinued in most barracks, and water latrines are used. The latrines are placed at some little distance from the rooms, and are usually connected with them by a covered way; in almost all barracks they are Jenning's or Macfarlane's patents. These are metal or earthenware troughs, which are one-third full of water. Twice a day a trap-door is lifted, the latrine is flushed, and the soil flows into a sewer or tank at a distance. A hydrant is now frequently placed close to the latrine; an india-rubber pipe can be connected with it, and the seats and floor of the latrine are thoroughly washed in this way twice daily. Probably it would be difficult to suggest anything better than this, although soldiers can be taught to use water-closets like other people, and not to damage them. If water-closets are used, a plan suggested by Mr. Williams, C.E., clerk of the works at Gravesend, seems a very good one. It is to have the water-closets at the top of a two-storied building, to the central part of which they form a small third story. In this way the following advantages are secured:—vicinity to the men—under the same roof, yet with perfect ventilation; impossibility of effluvia passing down; proximity to the cistern; and a good fall. At present, however, it seems better to keep to the water latrines outside the barracks.

Cavalry Barracks.

In many cases the men's rooms are placed over the stables, and there has been much discussion as to whether this arrangement is a good one. On the one hand, the men get more room, as the horses cannot be crowded, and they are near their horses. On the other hand, there is strong evidence that the effluvia from the stables pass into the men's rooms overhead;[1] and although I have been able to find no statistical proof that this has produced sickness among the men, we may safely *a priori* conclude that it is objectionable. The evidence of mews in London is not in point, as they are often close, ill-ventilated courts, independent of the stables in them. Besides, this evidence is as yet rather contradictory.

The question has, however, been solved by a "Report on the Ventilation of Cavalry Stables" (1863),[2] by the Barrack Improvement Commissioners, who have shown that the ventilation and lighting of stables can only be

[1] See especially the evidence of Mr. Wilkinson, Principal Veterinary Surgeon to the Army; Report of Barrack Committee (1855), p. 136, question 2262; also the Report on the Ventilation of Cavalry Stables (1863).

[2] Report of Barrack and Hospital Improvement Commission, signed by Sir Richard Airey, Captain Galton, Dr. Sutherland, Dr. Logan, and Captain Belfield.

satisfactorily carried out in one-storied buildings, and who, therefore, recommend that the men's rooms shall not be placed over stables.

Stables.—The medical officer has no duties connected with stables, except to see that they are in no way injurious to the health of the men; but it may be well to give the suggestions lately made by the Barrack Improvement Commissioners.

In all the old stables, if it is not already done, ventilating shafts are to be carried up, air-bricks introduced, and more window space to be given.

Whenever stables are to be built in future, it is recommended that the building should be one-storied; that the breadth should be 33 feet; the height of the side walls to the spring, 12; and of the roof, 8½ feet more. The breadth of each stall is to be 5½ feet, and there are to be only two rows of horses in each stable. Each horse is to have 100 superficial feet, and 1,605 cubic feet; the ventilation is by the roof, and is formed by a louvre 16 inches wide carried from end to end, and giving 4 square feet of ventilating outlet for each horse. A course of air-bricks is carried round at the eaves, giving 1 square foot of inlet to each horse; an air-brick is introduced about 6 inches from the ground in every two stalls. There is a swing window for every stall, and spaces are left below the doors. In this way, and by attention to surface drainage and roof lighting, it is anticipated that stables will become perfectly healthy. Some experiments were made some years ago by Dr. de Chaumont on the air of some artillery stables at Hilsea. In one stable, with 32 ventilators, and with 655 cubic feet per horse, the total CO_2 was 1.053 volume per 1,000; in another, with 1,000 cubic feet per horse, and with 420 air-bricks, 25 windows, and a ridge opening, it was .573 volume per 1,000. The last experiment shows great purity of the air.

Reports on Barracks.

The Regulations order the form in which reports on barracks shall be sent in. The arrangements should be strictly followed; it comprehends site, construction, external ventilation, internal ventilation, basements, and administration. It is then certain that no point will be overlooked; and, if nothing can be made out after going thoroughly through all the headings, it may be concluded that the cause of any prevailing sickness must be sought elsewhere. The site and basement should be especially looked at; every cellar should be entered, and the drainage thoroughly investigated. Little can be learned by merely walking through a barrack room, which is nearly sure to look clean, and may present nothing obviously wrong. With respect to ventilation, the statements of soldiers can seldom be trusted; they are accustomed to vitiated air, and do not perceive its odor. The proper time to examine the air of a room is about 12 to 3 A.M., and the medical officer should, accordingly, visit barrack rooms between midnight and 3 A.M. every now and then. The cisterns should be regularly inspected.

The walls and floors of the rooms should be carefully looked to. Walls are porous, and often become impregnated with organic matter. If there is any suspicion of this, they should be scraped and then well washed with quicklime. The medical officer should see that the lime is really caustic; chalk and water does little good. Collections of dirt form under the floors sometimes, and a board might be taken up to see if this is the case.

Sub-Section II.—Barracks in Forts and Citadels.

In fortified places it is, of course, often impossible to follow the examples of good barracks just given. Citadels may have little ground space; buildings must be compressed, guarded from shot, made with thick and bomb-proof walls, with few openings. Buildings are sometimes underground. Drainage is often difficult, or impossible; and if to all these causes of contamination of air we add a deficiency of water, which is common enough, it will not surprise us that the sickness and mortality in forts, in even healthy localities, are greater than should be the case. Both at Malta and Gibraltar there has for years been too large a mortality from typhoid fever, and from the destructive lung diseases, which appear in the returns as phthisis. The special difficulties of casemates are as follows: dampness, which is very common in all casemates, so that the moisture often stands in drops on the walls; a low temperature; a want of ventilation; and a want of light.

How these difficulties are to be met is one of the most difficult problems the military engineer has before him. How, without weakening his defences, he is to get light and air into the buildings, and an efficient sewerage, would test the ingenuity of a Brunel. It is possible that the best plan would be by the employment of thick movable iron doors and shutters. In time of peace these might be open; in time of war easily replaced. But, in addition, means of ventilation must be provided when such defences close the usual openings; tubes must be carried up, and, if necessarily winding, an enlarged area might, perhaps, compensate for this.

It must be said, also, that it is quite certain that in our fortified places many of the arrangements are much worse than they need be, and that the sanitary rules deducible from home experience should be applied in every case when the defensive properties are not interfered with.

Sub-Section III.—Barracks in Hot Climates.

The older barracks in both the East and West Indies were often merely copies of the English barrack square. In some cases, also, the exigencies of defence led to a cramped and irregular plan, and owing to the little attention which was paid either to the health or comfort of the soldier, overcrowding and deficient ventilation were as common in the tropics as at home. For several years there has been a gradual improvement, and in India especially vast and extensive palaces have been reared in many stations, which testify at any rate to the anxiety of the Government to house their soldiers properly.[1]

It will be desirable to refer here chiefly to the Indian barracks, but the same principles apply to all hot countries.

[1] Some of these great barracks, as at Allahabad, have not given satisfaction, and have been found as hot or even hotter than the old barracks. But this appears to have been from not attending to the rule, never to let the sun's rays fall on a main wall, but to shadow the wall by a veranda. The double roof also has apparently not been sufficiently double, *i.e.*, the openings above and below, to allow the air to circulate, have not been large enough; ventilators have also not been put to the verandas, so that the heated mass of air cannot ascend. Nothing tends to cause greater heat than stagnancy of the air, as may be seen by the ease with which water may be boiled in a close vessel by the rays of the sun, even in England. The objection to the palaces which have been built in India since the mutiny is not so much to the principle of the barracks, but to some faults in construction, and especially to their localities, viz., in the plains instead of in the hills in many cases.

The Indian Sanitary Commission have recommended that each man in barracks shall have 100 superficial feet, and 1,500 cubic feet. The Government of India recommended in 1864 that there should be 90 superficial feet in the plains, and 77 in the hills, which, with a width of 24 and 22 feet, and height of 20 and 18 feet, would give 1,800 cubic feet in the plains and 1,408 in the hills. Mr. Webb,[1] who has paid great attention to the subject of overcrowding in Indian barracks, and who believes that it is the grand cause of insalubrity in India, has adduced good reasons for thinking that this amount is not nearly sufficient. It is suggested, indeed, that 3,000 cubic feet of space is not too much.

In 1857 and 1858 the Bengal Government ordered standard plans to be prepared, and some barracks have been built in accordance with them. A description and figures will be found in the former editions of this work. In 1863 the Governor-General of India in Council ordered a renewed inquiry into the matter, and Colonel Crommelin submitted altered designs for barracks, which were subsequently submitted to the Bengal, Madras, and Bombay Governments, and to the Army Sanitary Committee at home. The plan of these new barracks is essentially that proposed by the Indian Sanitary Commission; while the preparation of the detailed design is left to the local officers, certain general principles are strictly laid down, and standard plans suitable for different localities are furnished for different guidance. The number of men to be placed under one roof is fixed at 40 or 50 (half-company barracks), except under exceptional circumstances; the number of men in one room is to be 16 to 20, and not to exceed 24; the barracks are to be two-storied in the plains, and one or two storied in the hills, both floors being used for dormitories; single verandas of 10 or 12 feet wide surround these rooms. There are to be only two rows of beds in the dormitories; the beds are to be 9 inches from the wall, and only two beds are to be in the wall space between two contiguous doors (or windows); in the plains each bed is to have 7½ feet of running wall space, in the hills 7. The general arrangements of the building are based on the suggestions of the Royal Indian Sanitary Commission. At each end of the dormitory are closets and night urinals; and what appears to be the best plan places these at the extreme end of the veranda, leaving a space between them and the dormitory.

The lower story in the plains was intended to be used as a day-room, but it appears that this has not been comfortable for the men, and both floors are now used as dormitories.

The married people's quarters are to be grouped in small one-storied blocks, each block holding the married people of a company or troop. Two rooms (16 feet × 14 feet and 14 feet × 10 feet) are provided for each family; verandas, 12 and 10 feet wide, are provided.

In all these arrangements it will be perceived that the essential principles of the home barracks are preserved; long, thin, narrow lines of buildings, with thorough cross ventilation, with the sleeping-rooms raised well off the ground, would certainly appear to be as good an arrangement as could be devised. A few more remarks on some of the points have to be made.

1. *Size of Houses.*—If there are no strong military reasons to the contrary, it seems certain that it is even more important in India than in Eng-

[1] Remarks on the Health of European Soldiers in India, p. 50. By H. Webb. Bombay, 1864.

land to spread the men over the widest available area, and not to place more than fifty men in a single block, and twenty-five men in a single room; and therefore, the proposed plan is most desirable. There has been an objection raised, that small detached houses in the hot plains of India, not having any large space in shadow, get everywhere heated by the sun's rays, and become very hot. The objection is theoretical; it is the immense blocks of masonry used in the construction of large buildings which are to be avoided as much as possible, since, once heated, they take hours to cool.

2. *Arrangement of Houses.*—Broadside on to the prevalent wind, and disposition *en échelon*, as now adopted in India, is obviously the proper plan. The only exception will be when there are marsh or gully winds to be avoided, and then the houses should be placed end on to the deleterious wind; and no windows should open on that side. But it is seldom such a site would be selected or kept.

If a barrack is built on a slope, and the ground is terraced, the Army Sanitary Committee have recommended that the barrack should be placed end on to the side of the hill, and not nearer the slope than 20 to 30 feet. But terracing should be avoided as much as possible.

3. *Breadth of Houses.*—As in England, it is important to have only two rows of beds in each house, and to keep the houses under 30 feet in width, so as to permit effective perflation. A single veranda is as good as a double one in keeping off the direct rays of the sun from the walls of a house, and two verandas (one inner and one outer) add to the breadth to be ventilated. The width of the verandas must be 10 to 12 feet; and on the southern and western sides wooden jalousies may have to be placed so as to occupy 3 or 4 feet at the upper part of the veranda.

Verandas should be ventilated by openings at the highest part, so as to have a free movement of air through them; this is very important. If there are two stories, the roof of the upper veranda should be doubled.

Materials of Building.—On this point there is little choice, for the risk of fire renders the use of wood undesirable for walls and roofs. And yet, apart from this risk, loosely joined wood, or frames of bamboo, have the great advantage of allowing air to pass through the walls. Brick or stone has therefore to be used. In India, sun-dried brick (*kutcha*), covered with cement, or faced with burnt brick, is often used; and the remains of Babylon or Nineveh show how imperishable a material this is if properly protected. It is said to be a cooler material than burnt brick (*pucka*), but it absorbs a great deal of moisture.

Iron barracks were sent out from England during the mutiny, but were said to be hot, and were not liked; but iron frames have been usefully employed, the intervals being filled up with unburnt bricks. There is, however, a very general feeling against unburnt brick, on account of the moisture it absorbs and retains. The concrete walls now coming into so much use in England would be particularly adapted for India; they are cheap, and are dry.

Construction of the Building.—The three points to be aimed at are—avoiding the malaria and dampness of the ground, should there be any risk of this; insuring coolness; providing ventilation.

(*a*) *Employment of Open Arches for the Basement.*—The extraordinary diminution in the risk of malaria by elevating the building only a few feet above the ground, and allowing a free current of air under the house, is illustrated in various parts of the world; along the banks of the lower Danube, in the plains of Burmah and Siam, etc. But another great benefit

is obtained: dryness and freedom from pent-up, stagnant, and often septic masses of air are insured, so that, even when the soil is not distinctly malarious, buildings should be raised. In a malarious country the height of the ground-floor above the ground should be 8 or 10 feet; in non-malarious districts 3 or 4 feet are sufficient, but it should always be high enough to allow cleaning.

If high enough, these open spaces afford excellent spaces for exercise during the heat of sun.

(*b*) *Walls.*—Very thick brick walls do not add to coolness (Chevers), but being thoroughly heated during the day, give out heat all night. The direct rays of the sun should not be allowed to fall on any part of the main wall. This will be found one of the most important rules for insuring coolness. Double main walls, with a wide space between, and free openings above and below, so as to admit a constant movement of air between, is the coolest plan known. Considering the excellent ventilation which goes on in bamboo and wooden houses, it may be a question whether, in the warm parts of India, the walls might not be made as far as possible permeable; at any rate, above the heads of the men. Whitening the outside walls reflects the heat, but is dazzling to the eyes; almost as good reflection, and much less dazzling, is obtained by using a slight amount of yellow or light blue color in the cement or lime-wash.

(*c*) *Floors.*—The materials at present used are flagstones (in Bengal), slates (in some barracks in the Punjab), greenstone (in some Madras barracks), tiles, bricks placed on end and covered with concrete, pounded brick and lime beaten into a solid concrete and plastered with lime, broken nodulaled limestone or kunkur (in places where the masses of kunkur are found, as in Bengal), asphalt, pitch and sand, wood (Chevers). Of these various materials, the asphalt gets soft and is objectionable; the cements and kunkur wear into holes, produce dust, and have been supposed to cause ophthalmia (Chevers); wood is liable to attacks of white ants, etc.

On the whole, it would seem that good wood (if there be a space below the barracks) with brick supports is the best, and after this tiles.

(*d*) *Roofs.*—Double roofs are now usually employed, and are made slanting, and not terraced. The terraced roofs, if made single (*i.e.*, with battens on the joists covered with kunkur), conduct heat too freely; but if nade double, with a good current of air, there is an advantage in giving a promenade to the men, and also, at some seasons of the year, the roof may be most advantageously used as a sleeping-place.

The sloping roofs are better adapted for ventilation. The coolest roof is made of thatch, covered with tiles; it would be cooler still if the thatch were outside; but thatch is dangerous on account of fire, and harbors vermin and insects. If there is a good space between the two roofs (2 feet), and if there are sufficient openings to permit a good current of air, perhaps two tile roofs would be as cool as any.

(*e*) *Doors and Windows.*—These are now always made very numerous, and opposite each other, so as to permit perfect perflation. The official "Suggestions" order one window for every two beds. Five doors are recommended for each room of twenty-five men; and Norman Chevers gives a good rule: A light placed in the centre at night should be seen on all sides. Upper as well as lower windows—a clerestory, in fact—are useful; the lower windows should then open to the ground. In most of the stations in Northern India the windows must be glazed.

The Committee appointed to carry out the suggestions of the Indian Sanitary Commission have recommended that each window should consist

of two parts—the upper portion, about 2 feet in depth, being hinged on its lower edge to fall inward, so as to direct the currents of air toward the ceiling of the room.

Ventilation of Tropical and Subtropical Barracks.

If barracks are not made too broad, and are properly placed, the same principles of ventilation may be applied to them as to barracks at home. The perflation of the wind should be obtained as freely as possible. The numerous doors and windows, however, render it unnecessary to provide special inlets; outlets should, as at home, be at the top of the room, either along the ridge, or if of shafts, they should be carried up some distance; if they are made of masonry, and painted black, the sun's rays will cause a good up-current. The area of the shafts is ordered[1] to be 1 square inch to every 15 or 20 cubic feet, with louvres above and inverted louvres below. In the lower rooms these shafts are to be built in the walls; in the upper rooms to be in the centre.

In many parts of India, however, at particular times of the year, the air is both hot and stagnant; in such stations artificial ventilation must be employed, and the forcing in of air offers greater advantages than the method by aspiration. The wheel of Desaguliers was introduced into India many years ago by Dr. Rankine, and, under the name of "Thermantidote," is frequently used in private houses and hospitals. Wheels may be used of a larger kind, and driven by horses and bullocks, or steam or water power. The great advantages are that the air is put in motion and can be cooled by evaporation.

An Arnott's pump, made as large as a man can easily work, will be found to be cheaper, and as good as the thermantidote.

The common punkah is a ventilator, as it displaces masses of air; the waves pass far beyond the building, and are replaced by fresh air-waves entering in. An improved punkah, worked by horse or bullock, and supplied with water for evaporation, was devised by the late Mr. Moorsom, of the 52d Regiment; it is described and figured in the "Report of the Indian Sanitary Commission," and would seem likely to be a very useful modification of the common punkah.

Ventilation in most parts of India must be combined with plans for cooling, and often for moistening the air.

Cooling of Air.—When the air is dry, *i.e.*, when the relative humidity is low, there is no difficulty in cooling the air to almost any extent. If the air be moving, this is still easier. The evaporation of water is the great cooling agency. A drop of water in evaporating absorbs as much heat as would raise 967 equal drops 1° Fahr., or, in other words, the evaporation of a gallon of water absorbs as much heat from the air as would raise 4½ gallons of water from zero to the boiling-point. As the specific heat of an equal weight of air is ¼ that of water, it follows that the evaporation of 1 gallon or 10 lb of water will cool (10 × 4 × 967) 38,680 lb of air, or 477,637 cubic feet of air 1° Fahr.; or, to put it in another way, the evaporation of 1 gallon of water will reduce 26,216 cubic feet of air from 80° to 60° Fahr. If thoroughly utilized, 1½ gallon per head would be the allowance for twelve hours, but as the full work is never got out of any material, this quantity ought in practice to be doubled. In India the temperature of a hot dry wind is often reduced 15° to 20° by blowing

[1] Suggestions, p. 22.

through a wet kuskus tattie; but merely sprinkling water on the floors will have a perceptible effect on the temperature.

When the air is stagnant cooling is less easy. In India it is often attempted, in a still atmosphere, to insure coolness by creating currents of air either by the simple punkah or by thermantidotes; these act by increasing evaporation from the body, and they certainly do away with the oppressiveness of a still atmosphere. But evaporation of water must be also employed, as in Captain Moorsom's punkah just referred to, or in some other way.

In the case of a thermantidote, or Arnott pump, thin wet cloths suspended in a short discharge-tube, or ice suspended in it, or a bottle containing a freezing mixture, and with a wet surface, will answer equally well.

When water is abundant other contrivances may be employed. A stream of water issues from a small orifice with a high velocity, and impinging on a round iron plate about an inch or two from the orifice, is beautifully pulverized. Or the beautiful sheet-water fountains used to wash air for ventilation might be employed. In the old Roman, and some Italian houses coolness was obtained by a fountain in the central court; and where it can be done, the more common employment of fountains in the houses in the hot parts of India may be suggested.

Cooling is then easy when the air is dry, or is not moister than 70 per cent. of saturation; but when the air is very moist, and almost saturated, as is often the case, for example, in Lower Scinde, and is at the same time still, evaporation is very slow. What can be done? Of course, the air must be set in motion by mechanical means. But how is it to be cooled? Two plans suggest themselves—taking the air through a deep tunnel, and the employment of ice.

The tunnel plan was tried some years ago at Agra, and was not well thought of. But everything depends on the mode of making the tunnel. It must be deep enough to get into a cold stratum of earth.[1]

The Chinese, in the north of China, suspend lumps of ice in their rooms during the summer; but this seems a wasteful plan. Ice in tunnels would have a much greater effect. If the ice cannot be obtained, freezing mixtures might possibly be used, if the expense is not a bar.

Ablution Rooms.—In India, every private house, and almost every room in a house, belonging to a European, has its bath-room. And not only the luxury, but the benefit is so great, that bath-rooms should be considered essential to every barrack. For the usual purposes of ablution the plan now used on home service is the best; but it should be supplemented by shower-baths. In order that these shall be efficiently given, the old plan of carrying water by hand must be given up; shower-baths for a regiment could never be provided in this way; water in large quantity must be laid on in pipes, and cisterns at the top of every barrack should feed the ablution rooms, and supply water for the urinals. At least from 12 to 18 gallons daily should be allowed per head for shower-baths alone, and, if possible, more than this, as general baths should be also provided. So essential must baths be considered for health, that a large supply of water should be considered a necessary condition in the choice of site. The disposal of the water after use is a question for the engineer; but it must not be

[1] The recent investigations into the composition of the ground air give additional reasons for objecting to the tunnel plan, unless the utmost care were taken to prevent the ground air being delivered into the dwellings.

permitted to soak into the ground near the barracks; it might seem superfluous to notice this, if the custom of allowing the ablution water to run under the houses did not prevail at some stations.

Urinals.—Urine tubs are still used in many of the barracks in India, but their use should be discontinued as soon as possible. Evaporation is rapid, and decomposition soon sets in. Several army surgeons have pointed out that the atmosphere is greatly contaminated in this way, and some have considered that affections of the eyes are produced by the ammoniacal fumes. Earthenware or slate urinals should be used, with water running through them; and if there are no drains to carry off the urine, a zinc pipe may be laid inside the building, and open into a tub below, which should be emptied daily.

The War Office Committee [1] recommended Mr. Jenning's urinal, which consists of a basin, valve, and siphon-trap, supplied with water. It is cleaned and filled by raising the handle. As already noticed in the Home Barracks, the suggestion of a small water-tap above, to allow the means of ablution, seems an excellent one.

Sub-Section IV.—Wooden Huts.

Of late years the use of wooden huts, both in peace and war, has greatly extended in several of the European armies. In peace, their first cost is small, and they are very healthy. In war, they afford the means of housing an army expeditiously, and are better adapted for winter quarters than tents.

The healthiness of wooden huts doubtless depends on the free ventilation; when single-cased, the wind blows through them; and even when double-cased there is generally good roof and gable ventilation.

Numerous patterns of huts have been used in our own and other armies, from small houses holding six men to the large houses designed by Mr. Brunel for Renkioi Hospital, and which were 25 feet high in the centre, 12 feet at the eaves, and held 50 men. In the Crimea the most common sizes were for 12, 18, and 24 men. Lord Wolseley thinks the most useful size is 32 feet long, 16 wide, 6 feet to eaves, and 16 to ridge, to hold 28 men; two huts are put end to end, with one chimney between them. If protection has to be obtained against wind, make a wall a foot away.

In arranging lines of huts, as much external ventilation and sunlight must be secured as possible for every hut. According to circumstances, the arrangements in lines, or *en échelon*, etc., must be adopted.

In time of peace huts are sure to be put up well; to be properly underpinned; on a drained site, and well warmed.

War Huts.

In the putting up of huts in time of war, when everything is done more roughly, the following points should be attended to:—

Do not excavate ground, if possible; and never pile earth against the sides.[2]

[1] Suggestions, p. 24.

[2] While it is desirable to have the walls as clear from accumulations outside as possible, it must be remembered that this rule, like others, has its exceptions. Thus, in a very cold country, like Canada, a sufficient degree of warmth could not be obtained in a wooden hut without piling snow up against the sides.

(*a*) *Floor.*—Whenever practicable, underpin the joists, so as to get a current of air under the floor. Arrange for the drainage underneath, so that water may not lie, but may be carried by a surface drain at once to an outside drain. If the floor is entirely of wood, have it screwed, and not nailed down,[1] so that the boards may be taken up, and the space below cleaned. If the sides are of planks, and the centre of earth, pave the centre with small stones, if they can be got, so that it may be swept. If this cannot be done, remove a little of the surface earth every now and then, and put clean sand or gravel down.

(*b*) *Sides.*—If the sides are double, leave out a plank at the bottom of the outside, and at the top of the inner lining. If the sides are single, make oblique openings for ventilation above the men's heads, with wooden flaps falling inward, and capable of being pulled more or less up, and inclosing the opening. Place a plank obliquely along the bottom at the outside, to throw the drip from the roof outward, so that the water may not sink under the houses. Whitewash both inside and outside of the planks.

(*c*) *Roof.*—Arrange for ridge ventilation. If felt is used, let the strips run along the sides, and not over the ridge, and beginning at the bottom, so that each successive strip may imbricate over the one below it; use no nails, but place thin strips of board across the strips from the ridge downward, to hold the felt down. Tarred calico is as good as felt.

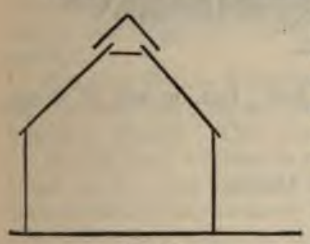


Fig. 101.

Warming.—In cold countries, if stoves are provided, place them at one end, and let the chimney run horizontally along above the tie-beams, to the other end, and open at the gable; in this way, the heat is economized; or put a casing of wood round the stove, except in front, and allow fresh air to pass between the stove and casing. If no stoves are provided, and a fire-place is made with stone, it should be put at one end, and a wooden trough running out at the gable be used as a chimney. If a good broad slab of stone can be obtained for a hearthstone, dig a trench under the boards and lead the air from outside under the hearthstone, and provide an opening at the other side of the stone. In this way the entering air is warmed.

Trenches should be carried round huts as in the case of tents.

Fig. 102 shows a plan much used by the Germans in 1870–71 for temporary sheds; the crossing of the rafters permits thorough roof ventilation, and the raising from the ground where practicable is very important.

Causes of Unhealthiness of Wooden Huts.

1. *Dampness from Ground, Earth against Wall, etc.*—Drain well. Cut away ground from outside; have good trenches round, with a good fall.

2. *Substances collecting under Floors.*—Look well to this as a common cause of unhealthiness.

[1] If possible the screws should be of copper, not iron; if of iron, each screw ought to be dipped in oil before being put in; this greatly increases the ease with which they can be withdrawn, and also saves the wood to some degree.

3. *Earth round Huts saturated with Refuse, Urine, etc.*—Every now and then clear away the surface earth, and replace it with clean dry earth.

4. *Ventilation* bad from too few openings.

5. *Cold.*—Issue extra clothes, if additional fuel cannot be obtained. See

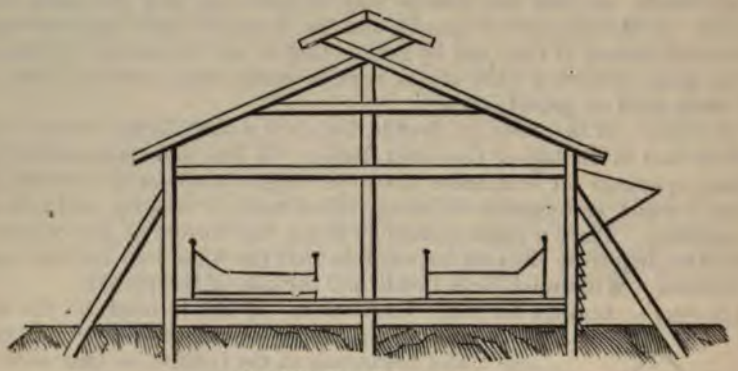


Fig. 102.—Plan of German Shed.

that the greatest effect is obtained from the fuel; but do not, if it can possibly be helped, close the ventilators.

Sub-Section V.—Tents and Camps.

Tents.

A good tent should be light, so that it may be easily transported, readily and firmly pitched, and easily taken down. It should completely protect from weather, be well ventilated, and durable.

It is perfectly easy to devise a tent with some of these characteristics, but not to combine them all.

The tents used in our army are as follows:—

Home Service.

The Bell Tent.—A round tent with sides straight to 1 or 2 feet high, and then slanting to a central pole. Diameter of base, 14 feet; height, 10 feet; area of base, 154 square feet; cubic space, 513 feet; weight, when dry,[1] about 65 to 70 lb. The canvas of the new pattern is made of cotton or linen. The ropes extend about 1½ foot all around. It holds from twelve to sixteen men; and in war time, even eighteen have been in one tent. The men lie with their feet toward the pole, their heads to the canvas. With eighteen men, the men's shoulders touch. Formerly, there was no attempt at ventilation; but afterward a few holes were made in the canvas near the pole. Ventilation, however, was most imperfect.[2] Dr. Fyffe (formerly of the Army Medical School), who carefully examined this point, found the holes so small that the movement of air was almost imperceptible. There is little ventilation through the canvas, and none at all when it is wet with dew. The new circular tent is somewhat improved as regards ventilation.

[1] Complete wetting of a tent adds from 30 to 40 per cent. to the weight.

[2] Barrack Improvement Report, p. 107.

The Hospital Marquee.—An improved hospital marquee was issued in 1866. It is in principle the same as the old marquee, but with improved ventilation. This tent is two-poled, with double canvas. It is made of a lower, almost quadrangular part, and an upper part, sloping from the top of the straight portion to the ridge.

A new pattern measured in 1872 was 28 feet long, 14 feet in width in the quadrangular part, 5 feet high to the top of the straight part, and 12 feet high from ground to top of ridge; the ground space was 353.4 feet, and the cubic space 2,766.6 feet. This is rather smaller than the old pattern.

It is intended for sick, and can accommodate ten men well; eighteen is the regulation, and twenty-four men have been put in it; but this crowds it extremely. There are ventilators, and a large flap at the top can also be opened for ventilation, and the fly can be raised. Its weight (including the valise) is about 500 lb. A waterproof sheet is now supplied, to put on the ground, and this weighs 145 lb.

It is a good tent when care is taken with ventilation; but there should be a way of raising one whole side, so as to expose every part of the tent; and if the height of the upright part were 6 feet, it would be more convenient.

Circular Tent.—A double circular tent, weighing about 100 lb, has been approved of for hospital purposes, into which four sick or wounded men would be placed. This forms part of the new field equipment.

Shelter Tent.—There is no official shelter tent for the English army on home service, but one was formerly issued for service at the Cape. Each man carried a canvas sheet, made up of a quadrangular (5 feet 9 inches × 5 feet 3 inches) and of a triangular piece (2 feet 8 inches height of triangle × 5 feet 3 inches base). Buttons and button-holes were sewn along three sides, and a stick (4 feet long, and divided in the middle), and three tent pegs and rope also were provided. Two or four of these sheets could be put together, the triangles forming the end flaps. A very roomy and comfortable shelter tent, 4 feet in height, was formed, which would, with a little crowding, accommodate six men, so that two sheets could go on the ground. The objection to this tent was its weight, viz., 6 lb 14 ounces per man. If a thinner material could be obtained, and if the size could be a little lessened in all directions, it would be a very good tent. Dr. Parkes attempted to arrange a cape and waterproof sheet in such a way as to form a tent when suspended on rifles.[1] A plan for making a shelter tent with blankets is given in the "Instructions for Encampments," 1877, p. 19, paragraph 14.

Officers' Tents.—Marquees are allowed, one for each field-officer; each captain, and every two subalterns, have one circular tent. The officers' marquee weighs 176 lb.

On Indian Service.

The tents for Europeans are marquees, with two poles and ridge, double fly. Length, 21 feet; breadth, 15; height to inner fly, 10 feet 3 inches; and outer fly, 11 feet 9 inches. Twenty-five infantry are accommodated with 85 cubic feet per man; or twenty cavalry, with saddles, with 100 cubic feet.

The tents for natives have a single fly. Length, 22 feet; breadth, 12;

[1] Army Med. Depart. Report for 1870; 1872, p. 260.

height of pole, 10 feet; to accommodate twenty cavalry, or twenty-five infantry.

French Tents.—In the French army two chief kinds of soldiers' tents were used.

1. The *tente d'abri*, or shelter tent of hempen canvas, which was intended for three or four men. This is now given up.

2. *Tente de Troupe*, or *Tente Taconnet.*—This is a two-poled tent, with a connecting ridge-pole. It is 19½ feet long, by 13 or 14 wide, and 10 high; the ground area is 243.5 square feet. It is intended for sixteen men. There are two openings in the centre, which can be held out by poles, each 5 feet in length, or closed at pleasure. Between the poles, at the height of 6 feet, there is a perforated wooden plank, on which articles are placed, or from which they hang. The total weight is 143.5 lb avoir. This tent is considered cumbersome and unstable, and is now being abandoned.

3. Two conical tents are also used, like the English bell tent; one (*tente conique*) a cone, and the other having an upright wall 16 inches high, and then being conical above (*tente conique à muraille*). This last tent is ventilated at the top; a galvanized iron ring, 12 inches in diameter, receives the canvas, which is sewed round it. An opening is thus left of 113 square inches, which can be closed by a wooden top which rests on the top of the pole, and is buckled to the ring. Each tent holds twenty men. The *tente conique* is the one now chiefly used. Small tents called *tentes de marche* are now issued to officers, who formerly provided their own of various forms.

Prussian Tent.—This is a conical tent, with a single pole, like the bell tent of the English army; it is nearly 15 feet in diameter, the pole is 12 feet high; it holds fifteen men, and weighs 91 lb avoir. The floor space is 12 square feet and the cubic space 70 cubic feet per head.

Prussian Hospital Tent.—The ground-floor of the tent is a rectangle 62 feet long and 24 broad; the tent is 16 feet high; there are 6 or 8 poles; the area is 1,488 square feet. It is divided into three parts: a central, 52 feet long and 24 broad (=1,248 square feet), for the sick, and two rooms, each 5 feet long and 24 broad, for attendants, utensils, etc. Some of the tents are made with hollow iron poles, and there is a good hood for ventilation. Each tent could contain 20 to 22 beds, but only twelve patients are placed in it. It stands on an area of 80 feet by 40. Since 1862 the Prussians have treated many of the worst cases under such tents during the summer. The same practice has been adopted in the Austrian army for many years.

Russian Tent.—The infantry tent is quadrangular, 14 feet square and 7 feet high to the slope; there is a centre pole and four corner poles; it is intended for fourteen men, but only twelve are usually placed in it. Round the tent is a bench 1½ foot broad, and covered with straw mattresses and sheets (in the summer camps) for sleeping. A wooden rack round the centre pillar receives the rifles. The canvas can be partly or entirely lifted up. The officers' tents have double canvas.[1]

Northern American Tents.—At the commencement of the civil war the Sibley tent was much used. It is conical, 18 feet in diameter, and 13 feet high, with an opening for ventilation, and gives 1,102 cubic feet; often twenty or twenty-two men were held by one tent. Bell- and wedge-shaped tents were also used; the latter was 6 feet 10 inches long, 8 feet 4 inches

[1] From Heyfelder's Camp of Krasnoe-Selo, 1868.

broad, and 6 feet 10 inches high, with a cubic space of 194 feet. It held six men.

These tents, however, did not answer ; the ventilation was most imperfect, and in the summer of 1862 ponchos and shelter tents were issued, which in the army of the Potomac superseded the old tents.[1] The poncho is a piece of oil-cloth with a slit in the centre, through which the head is put ; two ponchos can form a shelter tent. The army of the Potomac spent the winter in improvised huts of logs or mud, with the shelter tent for the roof.

The larger tents are, however, still used for stationary commands, and for hospital purposes.

Other Plans.—A very great number of different kinds of tents are employed by different nations, and many plans have been proposed of late years.[2] Of these Edgington's square military tent, and Turner's and Rhodes' tents, are the best. The first is a single-poled pyramidal tent, with a second pole to sustain the entrance flap; it is 13 feet square, and will hold sixteen men. There are ventilating holes through the canvas at the top, protected by canvas. It weighs 90 lb.

Turner's tents are conical and oblong ; the pole is hollow iron, and is supported in a tripod, below which a stove can be placed, to which the pole serves as a chimney. Instead of ropes, galvanized wire and iron pegs are used, and wire ropes running from the pole to the circumference are used to sustain hammocks, and so raise the men from the ground. A tent for eighteen men weighs 300 lb. Turner's hospital tent is 60 feet long, 29 wide, and 18 high, and weighs 896 lb.[3] A great advantage of these and similar tents is that a stove can be easily used, and there is pretty good ventilation through the hollow pole. The raising of men off the ground is also a great advantage.

Major Rhodes' tent is a curvilinear octagon, which is made up by a frame of stout ash or bamboo ribs, which are stuck into the ground, passing through a double-twisted rope near the ground, and bent into the centre, where they meet in a wooden head fitted with iron sockets, to receive the ends of the ribs. The framework is not unlike an open umbrella. The rope through which the ribs pass is well pegged to the ground, and there are also outside storm-ropes, so that, both from the shape of the tent and its ties, no storm can blow it over. There is a good top ventilation through an opening protected by a leathern cap, and the canvas covering which contains the tent (when packed) can be divided into two parts, and buttoned inside the bottom of the tent, so as to prevent air from blowing in under the canvas.

A small tent (guard tent), capable of holding four or five men, is also used.

The hospital tent is made of two of these tents connected by a portion of tent made of ribs which run to a ridge pole. It is 30 feet long, 15 feet wide, and 10 feet high, but can be made of any length. The field tent weighs 100 lb ; the hospital tent, 395 lb. Both these seem excellent tents ; they give much more ground area, cubic space, and standing room, than any form of cone tent, and are more convenient, as there are no poles.

[1] Woodward, Outlines of the Chief Camp Diseases of the United States Army, 1863, p. 46.

[2] A very good description will be found in Major Rhodes' Tent Life and Encamping, 1859.

[3] Rhodes, p. 178.

General Conclusions.

The history of all wars in the temperate zone proves that men cannot war without protection from weather.[1] Both theory and experience show that the best arrangement for a soldier is that he should carry a portion of a shelter tent, which may at once serve him for a cloak on the march, and a cover at night, if he is obliged to lie out without pitching his tent, and which, joined to two or three other similar pieces, may make a tent to hold three or four. The French, however, have abandoned this system, believing that its advantages are more than counterbalanced by the extra weight the men have to carry. For camps of position, where troops are kept for months, and where there is less trouble about transport, larger tents can be used, and then either a tent like that of Major Rhodes', or a two- or four-poled tent like the Prussian, appears to be the best.

The French system, now adopted by the Americans, is in reality a very old one. The Macedonians used small tents which held two men,[2] and Rhodes figures a little shelter tent of the same form as the French, and holding apparently five men, which was in use in the British army in 1750.

At various times in late wars the English army have extemporized tents of this description, by suspending blankets over their firelocks. But it would be much better to have a good shelter tent, which would make the men independent of their bell tents, on emergency, and thus greatly lessen the baggage of the army, as well as protect the men.

An army could then encamp and house itself as fast as it could take up its ground, and so short is the time necessary for pitching the tent that even in heavy rain the men would not get wet. The men lie much more comfortably than in the bell tent,[3] and there is scarcely a possibility of its being blown down.

CAMPS.

Several regulations have been issued by the Quartermaster-General's Department,[4] and the "Queen's Regulations"[5] contain several orders which will be noticed hereafter. The Barrack Improvement Commissioners[6] also lay down certain rules which must be attended to.

Encampments are divided into two kinds—those of position, which are intended to stand for some time, and incidental camps. The camps are arranged in the same way in peace and war, as a means of training the men; but, of course, in peace the war arrangements need not be adhered to.

In the "Regulations and Instructions" issued in 1877 by the Quartermaster-General's Department, the following rules are laid down:—

1. That the means of passing freely through the camp should be maintained.

[1] The Franco-German war of 1870–71, does not negative the rule that shelter must be given in some way; the Germans in their camps hutted themselves, and in their marches found shelter in houses in the greater number of cases.

[2] Rhodes' Tent Life, p. 13.

[3] In some of the last China expeditions waterproof sheets were issued, of which the men made tents as well as cloaks. Dr. Parkes was told by a private soldier who carried one of these, that nothing more comfortable was ever issued to the men. His sheet was the last thing that a man would part with.

[4] Regulations and Instructions for Encampments, "Horse Guards," 1877. A great deal of very important information is given in this little book.

[5] Pocket edition, Section 8.

[6] Report, 1861, p. 168.

2. That the tents, bivouacs, or huts should be disposed with a view to the greatest amount of order, cleanliness, ventilation, and salubrity.

3. That the camp be as compactly arranged as possible, consistently with the above considerations.

Troops are ordered to be encamped in such a manner that they can be rapidly formed in a good position for action. This does not involve the necessity of encamping on the very position itself.[1] Although purely strategical or tactical considerations are of the first importance before an enemy, yet sanitary advantages must always be allowed great weight, and will, in most cases, govern the choice of ground if military reasons permit. Cavalry and infantry camps are directed to be formed with such intervals between their troops or companies as circumstances may require, or the general commanding may direct. Open column is usually the most extended order used ; but the camp may be so compressed as to give only 8 square yards per head.[2]

In front of the camp is the battalion parade, the quarter-guard being in front of all. Behind the men's tents are the kitchens, and behind these the tents of the officers ; then come the wagons, horses, drivers, and bâtmen ; next the ashpit and latrines, and on the boundary line the rear-guard. In fixed camps the latrines and kitchens may be pitched elsewhere, if found advisable.

The distances between different corps are, as a rule, to be 30 paces.

Cavalry are encamped in the same way, in columns of troops or squadrons ; 4 feet of space is allowed to each horse, which is picketed.

Artillery encamp with the guns in front, the wagons in two lines behind, and the horses and men on the flanks, the men being outside, the officers' tents being in rear. A battery of artillery, with 192 of all ranks and 154 horses, occupies a space of 175½ yards by 133 in open order, and 85 by 71½ in close order. Other arrangements are given in the "Regulations."[3]

On considering these arrangements, it is evident that the compression of the men is considerable. As in war it is not always easy to give space, the importance, even in a military point of view, of thoroughly ventilating the tents is obvious.

Compressed Camps.—Occasionally the tents have been placed much closer together. It is to be presumed that no military officer who regards the comfort or health of his men will ever do so without an imperative military necessity. Yet it has been occasionally done, and tents have been placed almost as closely as they could be, even when ground was available and no enemy was in front. Under these circumstances, an explanation of the reasons for not crowding the men together will undoubtedly satisfy the officer in command that he is sacrificing comfort, convenience, and efficiency to a false notion of order and neatness.

In the Crimea, many officers dug out the interior of their tents, leaving a small pillar of earth to support the pole ; a ledge of about 9 inches in width was also left all round the outside to serve as a shelf ; a great deal of comfort and shelter was thus given in cold winds, but it would be well to go to as little depth as possible unless the soil is dry.

[1] Regulations and Instructions for Encampments, p. 1, Section ii.

[2] Measurements in infantry camps are usually made in paces: 6 paces = 5 yards ; other camps are measured in yards.

[3] For numerous plates of camps, tents, kitchens, etc., the reader is referred to the Instructions and Regulations for Encampments, price 6d., which ought to be in the hands of every officer.

Points to be attended to in the Erection and Conservancy of Camps.

Dig a trench round each tent, 4 inches deep, and the width of the spade, and carry it into a good surface drain running in front of the tents, with a proper fall. Place the tent on the ground and do not excavate, or to a slight extent; in a camp of position, the tents can sometimes be raised on a wall constructed of stones, or even earth, if this can be plastered over. Whenever possible, let the floor of the tent be boarded, the boards being loose, and able to be removed. If there are materials, make a framework elevated a few inches from the ground to carry the boards. If boards cannot be obtained, canvas or waterproof sheets should be used; whatever is used, take care that nothing collects below, and move both boards and canvas frequently to see to this, and scrape the earth if it is at all impregnated. If straw is used for bedding, get the men to use it carefully; to place pegs of wood or stones, and make ropes of straw running from peg to peg, so that each man may keep his own place neat; or to make mats of straw of a triangular shape, and 3 or 4 inches thick. Take care that the straw is kept dry, and never allow the men to use green foliage or any damp substance. Have the sides of the tent thoroughly raised during the day, and even at night, to leeward. Whenever practicable (twice a week if it can be done), the tents should be struck, the boards taken up, the surface well cleaned, the worst part of the straw removed and burnt.

In a camp of position dry paths should be constructed between the different roads; latrines should be dug in rear of the stables, and not too near the kitchen, and *en échelon* with the camp; for a standing camp each latrine should be a trench 20 to 50 feet long, according to the size of the camp, 10 deep, and 2 wide at the top, and 3 at the bottom. The earth thrown out should be arranged on three sides. It should be screened by branches of trees, and several inches of earth should be thrown in every day.[1] When 4 feet from the surface, it should be filled in and another dug, the earth of the old one being raised like a mound to mark the spot. Close to it an urinal should be constructed, of a sloping channel, paved as well as can be, and leading into the latrines, or of a tub which can be emptied into it, and, as far as possible, men should be prevented from passing urine round their tents. In camps for a few days a trench 12 paces long, 2 feet deep, 2 feet wide at top and 1 foot at bottom, is sufficient.

A corps of scavengers should be immediately organized to clean away all surface filth, and to attend to the latrines and urinals. All refuse must be completely removed; it is a good plan to burn it. Both in peace and war, encamping ground should be often changed, and an old camp should never be re-occupied.

In addition to tents, the men may be taught, if possible, to house themselves. Huts of wattle should be run up, or wooden sheds of some kind. In war, men soon learn to house themselves. Luscombe gives the following account of the huts in the Peninsula:—

"A cork tree or evergreen oak with wide-spreading branches was chosen, a lower branch was nearly cut through, so as to allow the extreme points to drop to the ground. Other branches were then cut from adjoining trees and fixed in a circle in the ground, through the branch, on which their upper branches rested. Smaller branches were then interwoven to thicken the walls, and the inside was lined with the broom-

[1] The Regulations direct 2 or 3 inches of earth.

plant, which was thatched in. The door of the hut was put due east, so that the sun might pass over it before it reached the horizon."

This hut was very cool during the day, but *very cold* at night, and thus "very prejudicial to health."

Lord Wolseley states that many English officers and the Sardinians generally, in the Crimea, made comfortable huts in the following way:—A space was dug out 2½ feet deep, and the size of the hut; those made to contain 6 Sardinian soldiers were 14 feet 3 inches long, and 7 feet 1 inch wide in the clear. Gables were then built of mud or stone, or made of boards or wattle and daub; the gables were 2 feet wider than the excavation, so as to form a shelf all round; a door was in one and a window in the other. The fireplace was made of brick or mud, or simply cut out of the face of the earth in one of the side walls, a flue being bored in a slanting direction, so as to come out clear of the roof, and being provided with a chimney 2 feet in height. The pitch of the roofs should be at an angle of 45°.[1]

Underground huts are sometimes used in camps; they are, however, dangerous; they are often damp, and are difficult of ventilation. In cold, dry countries, however, they are warm, and the Turks have constantly used them in campaigns in winter on the Danube. They have, however, frequently suffered from typhus. If used, there should be two openings besides the chimney, so as to allow a current of air; and a spot should be chosen where it is least likely water will gravitate. But underground huts are always to be discouraged if any substitutes can be found. Sometimes the side of a hill is cut into, and the open top covered with boards and earth. This is as bad as an underground hut.

Hospital Encampment of 9 Marquees and 14 Tents.

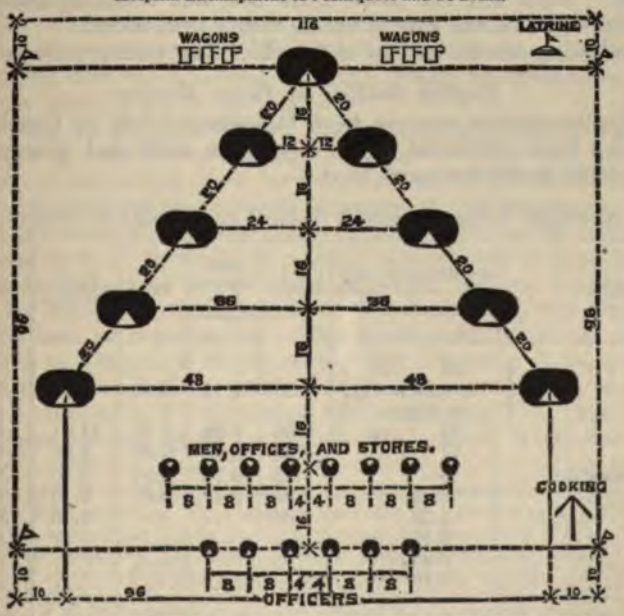


FIG. 103.—Measurements are in paces to centre poles of marquees. Total depth, 116 paces. Total length of front, 116 paces.

[1] Drawings of various kinds of huts and bivouacs are given in the Regulations, op. cit.

Hospital Encampment.

When marquees are available, and a good piece of ground can be selected, the best plan is to arrange the marquees in the form of a triangle. The figure shows the plan proposed by the late Surgeon-Major Moffitt, who paid great attention to this point. In the plan 9 marquees are arranged, but 3, 5, 7, or a larger number than 9, may be equally well placed in the same order. There is good exposure to air, and convenience in administration. The Regulation plan [1] is rather different, groups of 12 tents being arranged in lines, 5, 4, and 3, so as to alternate in position.

SECTION II.

THE FOOD OF THE SOLDIER—ARMY REGULATIONS.

The "Army Medical Regulations" place the food both of the healthy and sick soldier under the control of the medical officer. He is directed to ascertain that the rations of the healthy men are good, and that the cooking is properly performed; the amount of food for the sick is expressly fixed. On taking the field, the principal medical officer is ordered to advise on the subject of rations, as well as on all other points affecting the health of the troops. It will thus be seen that a great responsibility has been thrown on the Medical Department, and that its members will be called upon to give opinions on the quantity of all kinds of food supplied to soldiers; on the composition of diet; on the quality and adulteration of the different articles; and on their cooking and preparation.

In the case of soldiers and sailors, definite quantities or rations of food must be given. It is, of course, impossible to fix a ration which shall suit all persons. Some will eat more, some less, but certainly every scale of rations should err on the side of excess rather than defect.

The following are the rations of the chief European armies:—

English Soldier on Home Service.

The English soldier receives from Government 1 lb of bread, and ¾ lb of meat, and buys additional bread, vegetables, milk, and groceries. The following table shows his usual food:—

Nutritive Value in Ounces (avoir.) and Tenths of Ounces.

Articles.	Quantity taken daily in oz. and tenths of oz.	Water.	Nitrogenous Substances.	Fat.	Carbohydrates.	Salts.	Total Water-free Food.
Meat	12 oz. (of which ⅛th is bone).	7.20	1.44	0.81		.15	2.40
Bread	24 oz.	9.60	1.92	0.36	11.81	.31	14.40
Potatoes	16 "	11.84	0.32	0.02	3.36	.02	3.72 [2]
Other Vegetables [3]	8 "	7.28	0.14	0.04	0.46	.06	0.70 [2]
Milk	3.25 "	2.82	0.13	0.12	0.16	.02	0.43
Sugar	1.33 "	0.04			1.29	.00	1.29
Salt	0.25 "					.25	0.25
Coffee	0.33 "						
Tea	0.16 "						
Total Quantity..	65.32 oz.	38.78	3.95	1.35	17.08	.81	23.19

[1] Army Medical Regulations, 1878, Appendix, p. 225.

[2] *Some* indigestible *cellulose* not reckoned.

[3] Taken as *cabbage*.

Calculating this by the tables given at pp. 214–215, Vol. I., it would give—

		Grains.
Nitrogen		272
Carbon in albuminates	837	4,588
Carbon in fats	454	
Carbon in carbo-hydrates	3,297	
Hydrogen in albuminates	51	116
Hydrogen in fats	65	
Sulphur in albuminates		32

The quantity of nitrogen is considerably below that of the standard diet, while the amount of carbon is nearly correct, only this is given chiefly in the form of carbo-hydrates, and not as fat. The diet would be improved by the addition of more meat or of cheese, and by the addition of butter or of oil. So also, while fresh succulent vegetables are sufficient, the use of peas and beans, as in the French army, would be very desirable.[1]

Using the table at p. 218, Vol. I., and taking the bread $\frac{1}{6}$th crust and $\frac{5}{6}$ths crumb and the "other vegetables" as cabbage, the total energy obtainable in the body from the soldier's daily diet appears to be equal to lifting 3,542 tons one foot. The amount for the internal and external mechanical work of the body being taken at 600 tons lifted a foot, there remain 2,942 tons for the animal heat and all the other processes.

The accessory foods are rather deficient in the soldier's food, and vinegar especially should be used. Robert Jackson very justly insisted on the importance of vinegar as a digestive agent and flavorer, as well, no doubt, as an antiscorbutic. He remarks on the great use of vinegar made by the Romans, and possibly the comparative exemption which they had from scurvy was due to this.

The diet of the soldier on foreign stations is stated under the several headings when it differs materially from that of home service, and the alterations in the diet which should be made under circumstances of great exertions are given in the proper chapter.

In the time of Edward VI. the English soldier's rations during war were—meat 2 lb, bread 1 lb, wine 1 pint (Froude).

No scale of diet is laid down for war, and probably it would be fixed at the time, and in view of the possible character of the campaign. The war Scale should be very liberal, and every article ought to be issued by the supply Department. It would be probably a good plan to have the supply under two headings, the "usual" and the "extra" articles, the latter being intended for special occasions, such as forced marches, rapid movements far from the base of supplies, etc. The usual ration ought not to contain less than 375 to 400 grains of nitrogen. The following is suggested as a liberal and varied war ration, which could be easily supplied under ordinary cases:—Bread, 1¼ lb; fresh meat (without bone), 1 lb; peas or beans, 3 ounces; potatoes and green vegetables, 1 lb; cheese, 2 ounces; sugar, 2

[1] That the food of the English soldier is deficient, especially for the younger men, is known also from evidence. The late Director-General (Sir James B. Gibson) strongly urged on the authorities the desirability of increasing the ration of meat, and in the report on the recruiting of the army the same point was brought forward. Inquiries among soldiers showed that the recruits and young soldiers could eat much more; though the old soldiers, many of whom had been long accustomed to take spirits, and who had injured their digestive powers by so doing, took less food. There is no doubt that, taking the army through, the ration, especially of meat, is not enough. For further remarks, see "The Soldier's Ration," by F. de Chaumont, Sanitary Record, February 5, 1876.

ounces; salt, ½ ounce;[1] pepper, $\frac{1}{20}$ ounce; ground coffee, 1 ounce; tea, ½ ounce; red wine, 10 ounces, or beer, 20 ounces. No spirit ration to be given, except under order from the generals of divisions. The nutritive value of this diet is about 380 grains of nitrogen and 5,000 of carbon.[2]

The "extra" articles would be kept in readiness by the Supply Department for occasional issue, viz., salt meat, Australian meat, Chicago meat, dried meat (such as Hassall's or M'Call's, or the best market article of the kind), Liebig's extract of meat, pea and beef sausages, biscuits, flour, meat biscuits, rice, lime juice, preserved vegetables, brandy or rum, and vinegar.

This plan supposes that the "usual" scale of diet would be issued to the troops, and the "extra" articles under certain conditions, and under order of the general of the division.

Bread (which should be well-baked) should be issued as long as possible;[3] and if biscuit is issued for more than a week, flour or rice should be added to it. When salt meat is issued for several days in succession, vinegar should be given with it. If no vegetables can be obtained, lime juice should be early had recourse to.

The usual alcoholic ration of the troops should be beer or wine, instead of spirits. As all the continental armies issue wine rations in war, there can be no difficulty on the score of transport; and even with beer, though twice as bulky as wine, it is believed that it could be in most cases supplied.

But the issue of red wine instead of spirits is strongly urged.

For rapid expeditions, when transport has to be reduced to the minimum, the use of concentrated and cooked foods is all-important. The men can carry enough for seven or eight days, and are then independent of all base of supply.

Pea and flour sausages, meat biscuits, and dried meat, are the best to use; and the issue of cheese and bacon fat, if it can be obtained with these, gives a diet which is fairly nutritious and not disagreeable. The following would be the weight of food which would last a man for a week, and render him independent of the Commissariat during that time:—Biscuit, 2 lb; pea or flour meat sausage, 4 lb; dried meat, 2 lb; sugar, ¾ lb; tea, ¼ lb; cheese, 1 lb;—total, 10 lb. That is to say, a weight of 10 lb, which would be lessening day by day, would, if properly used by the men, carry them through a week's labor, and although, of course, a meagre diet, would yet enable them to do their work.

The extract of meat, as an extra ration, is intended for another purpose. It has a great restorative power, and should be kept for special cases, such as the following:—

1. It is expected the army, after a rapid march, will meet the enemy,

[1] It may be suggested that chloride and phosphate of potassium, and perhaps a little citrate of iron, might be added to the common salt.

[2] For further remarks see "Military Hygiene," a lecture by F. de Chaumont, Journal of the United Service Institution, 1870.

[3] Steam baking ovens have been used in the Autumn Manœuvres, and have been found very good. Field ovens were also built by iron hoops fixed in the ground. Lord Wolseley gives the following plan:—Take a barrel (with iron hoops, if possible), knock out the head, lay it on its side, after scraping a bed for it; cover it with a coating of 6 or 8 inches of thick mud, except at the open end; pile up sand or earth to a thickness of 6 inches over the mud; arrange a flue at the end distant from the open part, through the mud and earth, of 3 inches diameter, to increase the draught when the fire is burning. Form an even surface of well-kneaded mud at the bottom of the barrel; light a fire in the barrel, and keep it alight until all the wood is burnt; there will then be a good oven of clay, supported by the iron hoops. When heated for baking, the mouth is closed with boards, or a piece of iron or tin. These ovens were used in the Red River Expedition, and answered admirably.

and that there will be no time for preparing food. A small quantity of Liebig's extract, merely mixed with 3 or 4 ounces of red wine, will restore strength in a wonderful way; no cooking is required, and ten minutes' time will supply a whole regiment.

2. The force meets heavy weather, and every man is drenched. The issue of Liebig's extract, made into hot soup, and with wine added, will have a very great effect in preventing bad consequences.

3. A forced march has to be made in a very short time, and no fires can be lighted for cooking. Liebig's extract in small tins should be distributed to the men, who should spread it on their biscuits.

4. After action it is invaluable for wounded men, and can be carried about the field and given to the men who cannot be brought into the hospital.

It would be convenient to have the extract carried in cases holding small quantities, so that one pot may be issued to ten or twenty men.

The strength and use will require to be explained.

In war the supply of food is often difficult, but as an army "fights on its belly," the importance of food at critical movements cannot be overrated. The uncertainty of the time of supply, and the difficulty of cooking, often cause the men to be without food for so many hours as to exhaust them greatly; and some actions have been lost, others have remained without good result, from this cause. This can only be avoided by regimental transport of condensed and ready-cooked food, which may be used on such emergencies, and given in addition to the usual rations issued by the Supply Departments. The colonel of a regiment would then always be sure that he had the means of keeping up the strength and vigor of his men. The Germans are now trying a plan of cooking, which is intended to obviate one difficulty on the march.[1] A Viennese engineer (Herr Beuerle) has altered Papin's digester in such a way as to make it a convenient cooking utensil, and it is now in use in the Austrian ambulances. It is a doubly conic iron pot covered with a lid, and capable of standing the pressure of five atmospheres; the lid is fastened by screws, and a layer of felt or india-rubber is between it and the rim of the pot, so as to exclude air; in the lid is a ventilating opening, weighted to 2.5 ℔ (Austrian = 3.1 ℔ English), so that it opens when the pressure exceeds one atmosphere. The meat, salt, vegetables, etc., are put into this digester, and it is filled up with water till about 3 fingers' breadth from the top. The amount of water is 1 pint (English) to 1 ℔ of meat (English). This makes so strong a soup that it has to be diluted. The pot with the lid screwed down is put on the fire (three iron supports from which the pot hangs, like a gipsy's kettle, are provided for the field), and as soon as steam is developed, which is known by opening the ventilator a little, the fire is moderated. In an hour and a half the soup is ready. Pots to cook from eight to twenty-five rations are made, and special arrangements are made for cooking potatoes, etc. The plan is, in fact, in principle similar to Warren's compressed steam boilers, now used in the army, but is simpler.

One advantage in active service of this plan is, that if the troops are surprised, and have to move off their ground before the soup is ready, the pot is simply thrown into the wagon, and at the end of the march the soup is usually found to be ready.[2]

[1] Der Beuerle'sche Dampfkochtopf, Deutsche Militairarztliche Zeitsch., 1872, heft v., p. 215.

[2] In the Crimea, Soyer introduced various portable cooking stoves, but probably the compressed steam cooking will supersede all others. Soyer also gave several receipts

Rations of the French Soldier.[1]

In Time of Peace.

Under the Regulations of 1873, the Government furnishes the meat for the soldiers' rations at about 35 per cent. under market price. This has proved a great advantage for the soldier. The State also furnishes bread (*pain de maintien*) and fuel; the white bread (*pain de soupe*), as well as other articles, are bought from the funds of the *ordinaire*, or common fund of the company, battery, or squadron. To this the soldier pays 43 centimes a day, out of 48 that he receives, except in Paris, when his contribution is 51, out of a total of 58. The remaining 5 or 7 centimes he receives in cash.

Infantry of the Line.[2]

	Grammes.	Ounces avoir.
Munition bread	750	26.4
White bread for soup	250	8.8
Meat (*uncooked*)	300 [3]	10.6
Vegetables (green)	100	3.5
" (dried)	30	1.1
Salt	15	0.5
Pepper	2	0.073 = 31 grains.
Total	1,447	51.00

If biscuit is issued, 550 grammes (or 19.4 ounces) are given in place of bread. If salt beef is used, 250 grammes (8.8 ounces) are issued, or 200 (7 oz.) of salt pork. Haricot beans form the chief part of the dried vegetables.

Analyzed by the table for calculating diets, and deducting 20 per cent. from the meat for bone, the water-free food of the French infantry soldier is, in ounces and tenths—

	Water.	Albuminates.	Fats.	Carbohydrates.	Salts.	Water-free Food.
Meat	6.30	1.26	0.70		0.13	2.09
Bread	14.15	2.82	0.53	17.25	0.45	21.05
Vegetables (taken as cabbage)	3.19	0.01		0.21	0.02	0.24
Vegetables dried (as peas)	0.16	0.24	0.02	0.58	0.02	0.86
Salt					0.50	0.50
Total	23.80	4.33	1.25	18.04	1.12	24.74

In Algiers the ration of bread is also 750 grammes, or 26.5 ounces, and 8.8 ounces for soup, or biscuit 643 grammes. The meat is the same; 60

for field cooking, which were found to be very useful. A number of these receipts were printed in 1872 at the Royal Artillery Institution at Woolwich. In case of a war, it would be useful to print some receipts of the same kind, adapted to the particular sort of cooking-stove then in use.

[1] Code des Officiers de Santé, par Didiot, 1862, pp. 481 et seq. Alterations have been made in the scale of diet since 1874; the new scale is given in the text.

[2] As given by Morache, Traité d'Hygiène Militaire, 1874.

[3] 240 without bone = 8.4 ounces.

grammes of rice and 15 of salt are issued, and on the march, sugar, coffee, and ¼ litre of wine.

In Time of War (Morache).

	Total.	Water.	Albuminates.	Fats.	Carbohydrates.	Salts.	Water-free Food.
Meat (without bone)	8.40	6.3	1.26	0.70	...	0.13	2.09
Bread	35.30	14.1	2.82	0.53	17.25	0.45	21.05
Or Biscuit	(26.50)	...	...	...	...	...	...
Dried Vegetables	2.12	...	0.50	...	1.50	0.05	2.05
Salt	0.50	...	...	...	...	0.50	0.50
Sugar	0.70	...	...	...	0.70	...	...
Coffee	0.60	...	...	...	...	...	...
Total	45.82	20.4	4.58	1.23	18.75	1.13	25.69

The sugar and coffee are sometimes replaced by 25 centilitres (9 ounces) of wine, or 6¼ centilitres (2.2 ounces) of brandy.

German Soldier.[1]

The soldier receives his pay every ten days, *i.e.*, three times a month; it amounts to three thalers (or 9 shillings English) per month,[2] or 3 silbergroschen (= 3½ pence nearly) a day. Out of this he has to defray the cost of a warm dinner (*menage*) at the rate of 1¼ silbergroschen (=1½ penny); and he also receives a mess contribution, varying according to the market prices of food.[3]

The rations in time of peace are divided into the smaller and the larger victualling rations.[4]

	Smaller Ration, in ounces avoir.	Larger Ration for Marches, etc., as supplied from the Military Stores, in ounces avoir.
Bread	26.50	26.50
Meat (raw)	6.00	8.82
Rice	3.20	4.22
Or unhusked Barley (Groats)	4.21	5.28
Or Peas or Beans	8.22	10.60
Or Potatoes[5]	53.08	70.5
Salt	0.87	0.87
Coffee	0.468	0.468

[1] From information furnished by Dr. Roth, of the Prussian Army (now Surgeon-General, Saxon Army).

[2] Lance-corporals and privates which have engaged themselves to serve a longer term of years receive additional pay — 1 thaler (3 shillings) per month.

[3] In the new currency — 1 thaler = 3 marks; 1 mark = 100 pfennings; 1 silbergroschen = 10 pfennings.

[4] The Prussian weights are now assimilated to the French; the Prussian pound is = ½ kilogramme or 500 grammes; the loth = 16.66 grammes or .5870 oz. avoir.

[5] 25 per cent. is lost in boiling and peeling; besides smaller potatoes than the English kind are served out, occasioning still more waste.

These would furnish in their best form about the following (oz. avoir.) :—

Kind of Ration.	Albuminates.	Fat.	Carbohydrates.	Salts.	Total Water-free.
Smaller Ration	4.8	1.1	17.4	1.5	24.8
Larger Ration	5.7	1.4	18.6	1.6	27.3

Troops, when travelling on railway or on steamers, receive an additional pay of 2½ silbergroschen (= 3 pence) per man for refreshments. Should the travelling last longer than 16 hours, the additional pay is doubled.

In Time of War.—The supply of rations for the Germans during the Franco-German war was thus conducted :—

1. During the marches in Germany the men were billeted, and money was paid for their food.

2. Supplies were drawn from the magazines.

3. Supplies were obtained by requisition when the troops entered France. This last plan was a bad one, as was especially shown in the march to Sedan, where the Germans passed over a country previously nearly exhausted by the French. The principal defect was the great uncertainty and irregularity of the supplies ; some corps received too much, others too little, and the hospitals especially, which had not men to send out to get supplies, were particularly badly off. The quality of the food was also often bad ; so that, as far as the health of the troops is concerned, the system of supplies by requisition should be as little used as possible. It must be noted, however, here, that the Germans did not pay ready money, which might, perhaps, have attracted better supplies than the system of written vouchers. The magazine supplies were excellent, but occasionally failed in certain articles, as fresh meat, as a substitute for which the celebrated pea-sausage was issued. But it was found that if the pea-sausage was used too exclusively, the men disliked it. In fact, one of the greatest difficulties was the too great uniformity of the food. To do away with this, bacon, preserved and smoked meats, peas, and white beans, and potatoes, when possible, were issued as a change of diet. Independent of these extra issues, the daily German ration was as follows, in English weights :—

	Bread 26½ ounces, or biscuit,	17	ounces.
One of these	Fresh or salt meat.....	13	"
	Salted beef or mutton.....	9	ounces, or
	Bacon	5¾	"
	Rice.....	4.4	"
One of these	Barley or groats	4.4	"
	Peas or beans	8.8	"
	Flour	8.8	"
	Potatoes	3.3	lb
	Salt	0.7	ounce.
	Coffee	0.7	ounce of unroasted, or 1 ounce of roasted.

The want of knowledge of cooking was very great, and also the addition of articles to give flavor, as vinegar and spices, would have been much

prized. Roth strongly recommends the establishment of a school for cooking, like that at Aldershot.

The bread, owing to the long time it was on transport, was sometimes mouldy.

Austrian Soldier.[1]

In Time of Peace, receives—bread, 31 oz. avoir.; meat (without bone), 6.6; suet, 0.6; flour (or vegetables in lieu), 2.5; salt, 0.6. To this are added a little garlic, onions, and vinegar. These give about—

	Albuminates.	Fat.	Carbo-hydrates.	Salts.	Water-free Food.
In time of peace	3.7	1.6	17.0	1.0	23.3
In time of war[2] (mean)....	4.5	3.2	22.8	1.0	31.5

The amount of the peace ration is much the same as our own; there is too great a preponderance of bread, and there is too great sameness. The fat is in too small a quantity; the nitrogenous substances are too small.

In Time of War.—It is difficult to calculate the daily ration, as there is a weekly issue of many substances; the above figures are a mean taken from those cited by Meinert. On four days, fresh pork is issued; the total amount being 26 oz., or 6½ oz. daily. On one day, 6 oz. of salt pork; on one day, 6 oz. of beef; and on one day, 6 oz. of smoked bacon; altogether in the week, 44 oz. of meat are issued; and in addition, 1 oz. of butter or fat.

There are also issued per week:—24½ oz. of biscuit, 147 oz. of flour for bread, 29½ oz. of flour for cooking, 5½ oz. of pickled cabbage (sour kraut), 9 oz. of potatoes, 5½ oz. of peas, and 5 oz. of barley.

Wine, brandy, and beer are also given.

Russian Soldier.[3]

There are 196 meat days and 169 fast days in the year. On the *meat* days meat is given with schtschi (cabbage soup) and buckwheat gruel; on the *fast* days the meat is replaced by peas and (occasionally) fish. 42 oz. avoir. of rye bread are issued daily. This is large, but it is probably watery. Meinert[4] calculates the nutrition value as follows, oz. avoir.:—

Albuminates.	Fat.	Carbo-hydrates.	Salts.	Water-free Food.
5.8	1.0	25.0	2.5	34.3

On the march, 1¾ lb of biscuit (24½ English oz.) instead of bread. Brandy only on rare occasions, calculated at 135 fluid ounces per year (in 5 oz. rations).

[1] Kraus, quoted by Roth.

[2] Meinert, Armee und Volks-Ernährung, Berlin, 1880.

[3] For details of this diet, see Dr. Oscar Heyfelder's The Russian Camp at Krasnoe Selo, German edition, 1868, or former editions of the present work, or Roth and Lex, op. cit.

[4] Op. cit.

Sepoy Diet.—Dr. Goodwin has calculated the diet of a Hindu, such as a Sepoy servant, to consist of 4.387 oz. of albuminates; 1.278 oz. of fat; 18.584 oz. of carbo-hydrates; and .64 oz. of salts—total water-free food, 25.113 oz. It is thus a really better diet than that of the European soldier. The principal articles were 24 oz. of attar (ground wheat), 4 oz. of dholl (pea), and 1 oz. of ghee (butter). In other cases rice is more or less substituted for wheat. The Hindu diet consists of wheat, or of some of the millets (cholum, ragee, cumboo—see *Millets*), rice, leguminosæ (*Cajanus indicus*), with green vegetables, oil, and spices. If any kind of diet of this sort has to be calculated, it can be readily done by means of the analysis of the usual foods previously given. For example, a Hindu prisoner at labor in Bengal receives, under Dr. Mouat's dietary,[1] the following diet during his working days:—

	Total. oz.	Water. oz.	Album. oz.	Fat. oz.	Starches. oz.	Salt. oz.	Water-free Food.
Rice	20	2	1	0.16	16.64	0.10	17.9
Dholl (a pea, *Cajanus indicus*)	4.25	0.6	0.9	0.08	2.75	0.12	3.3
Vegetables (reckoned as cabbage)	6.0	5.3	0.1	0.03	0.34	0.04	0.5
Oil	0.33			0.33			0.3
Salt	0.33					0.33	0.3
Spices	0.33						
Total	31.24	7.9	2.0	0.60	19.83	0.59	22.4

In some Bengal prisons, 2 ounces of fish or flesh appear to be also given.

In the Looshai expedition the Sepoys received—rice, 1 lb; flour, 1 lb; ghee, 2 oz.; salt, 1.5 oz.[2] The nutritive value, if the ghee is calculated as butter, is 178 grains of nitrogen and 6,080 of carbon, which, though deficient in nitrogen, would appear to be a good diet in respect of carbon. Probably some peas were added.

SECTION III.

THE CLOTHING OF THE SOLDIER.

The structure and examination of fabrics have been already given.

Regulations.—No specific instructions are laid down in the "Medical Regulations" respecting clothing, but the spirit of the general sanitary rules necessarily includes this subject also. When an army takes the field, the Director-General is directed to issue a code for the guidance of medical officers, in which clothing is specially mentioned; and the sanitary officer with the force is ordered to give advice in writing to the commander of the forces, on the subject of clothing among other things.

[1] See Mouat's elaborate report On the Diet of Bengal Prisoners, Government Return, 1860, p. 49. The chittack is reckoned as the bazaar chittack, viz., = .1283 lb, or about 2 ounces avoir. Some useful information on prison and coolie diets will be found in a memorandum prepared by Surg.-Major I. B. Lyon, F.C.S., Chemical Examiner to the Government at Bombay, May, 1877.

[2] Indian Med. Gazette, March 1, 1872.

Formerly a certain sum, intended to pay for the clothing of the men, was allotted by Government to the colonels of regiments. This was a relic of the old system by which regiments were raised, viz., by permitting certain persons to enlist men, and assigning to them a sum of money for all expenses. The colonel employed a contractor to find the clothes, and received from him the surplus of the money after all payments had been made. A discretionary power rested with the service officers of the regiment, who could reject improper and insufficient clothing, and thus the interests of the soldier were in part protected.[1] The system was evidently radically bad in principle, and since the Crimean war, the Government has gradually taken this department into its own hands, and a large establishment has been formed at Pimlico, where the clothing for the army is now prepared. This system has worked extremely well; the materials have been both better and cheaper, and important improvements have been and are still being introduced into the make of the garments, which cannot fail to increase the comfort and efficiency of the soldier.

At the Pimlico depôt the greatest care is taken to test all the materials and the making up of the articles; the viewers are skilled persons, who are believed to be in no way under the influence of contractors.

In January, 1865, a warrant was issued containing the regulations for the clothing of the army, and several other warrants and circulars have since been promulgated. They are now consolidated in the "Regulations for the Supply of Clothing and Necessaries to the Regular Forces," 1881 (vol. ii., "Revised Army Regulations").

When a soldier enters the army he is supplied with his kit; some articles are subsequently supplied by Government, others he makes good himself. In the infantry of the line a careful soldier can keep his kit in good order at a cost of about £1 per annum. The following are the articles of the kit supplied to the infantry recruit:—

Clothing.

2 Frocks.
2 Pairs of trousers.
2 Pairs ankleboots (one each half year).
1 Forage cap and badge.

Necessaries.

2 Flannel shirts.[2]
3 Pairs socks (worsted).
1 Pair braces.
1 Pair mitts.
1 Hair comb.
1 Knife (table).
1 Fork.
1 Spoon.
1 Mess tin and cover.
2 Towels.
1 Piece of soap.
1 Sponge, pipeclay.
1 Razor and case.
1 Hold-all.
1 Tin of blacking.
1 Blacking brush.
1 Brass brush.
1 Cloth brush.
1 Polishing brush.
1 Shaving brush.
1 Button brass.
1 Kit bag.

[1] But this safeguard was not sufficient. Officers are not judges of excellence of cloth; for this it requires special training. As Robert Jackson said sixty years ago: "Soldiers' clothing is inspected and approved by less competent judges than those who purchase for themselves."

[2] By a Circular, November, 1865, flannel shirts only are ordered to be supplied to the recruit.

The kit is divided[1] into the surplus and the service kit. The former, consisting of 1 frock, 1 pair of socks, 1 shirt, 1 towel, 2 brushes, and such articles for the hold-all as are not wanted, is carried for the men. The service kit is supposed to be carried by the man, either on his person or in his knapsack.

Certain articles are also issued free of expense at stated intervals. For the particulars of these reference must be made to the "Regulations," 1881, where they are stated in detail. The following are the articles issued to the line infantry soldier at home :—

One helmet and bag	Quadrennially.
One tunic	Biennially.
One frock	Annually.
One pair tweed trousers	Annually.
One pair tweed trousers	Biennially.
Two pairs of boots, one on 1st April and one on 1st October	Annually.
One forage cap	Annually.
One silk sash for sergeants	Biennially.
One worsted sash for sergeants	Biennially.
One great-coat	Every five years.

In India and the West Indies, and other Tropical Stations, light clothing of different kinds is used—drill trousers and calico jackets, or in India complete suits of the khakee, a native gray or dust-colored cloth, or tunics of red serge, and very light cloth. The khakee is said not to wash well, and white drill is superseding it. The English dress is worn on certain occasions, or in certain stations. Formerly the home equipment was worn even in the south of India ; but now the dress is much better arranged, and also differences of costume for different places and different times of the year are being introduced.

During Campaigns extra clothing is issued according to circumstances. In the Crimea the extra clothing was as follows for each man :—

2 Jersey frocks.	1 Cholera belt.
2 Woollen drawers.	1 Fur cap.
2 Pairs woollen socks.	1 Tweed lined coat.
2 Pairs woollen mitts.	1 Comforter.

To each regiment also a number of sheepskin coats was allowed for sentries.

The "Regulations" of 1881 order the following articles of clothing to be issued to each man proceeding on active service in cold, temperate, or hot climates :—

1. *In Cold Climates.*

Sheepskin coats (for 100 men)	8	Drawers, flannel (per man) pairs	2
Fur caps (per man)	1	Cholera belts, flannel, pairs	2
Woollen comforters, "	1	Mittens, lined with lambskin or fur, pair	1
Jerseys, blue "	1		
Boots, knee, brown leather, pair	1	Pilot coat, each mounted man	1
Stockings, woollen, pairs	2		

[1] Queen's Regulations, 1881, section 12, par. 47.

2. *In temperate climates.*

Cholera belts, when not included in the voyage kit.....	2	Waterproof capes (for 100 men)..	10
		Watch coats " ..	3

3. *In tropical climates.*

White helmet (per man).....	1
Frock coat, of serge or tartan, when not supplied as ordinary clothing of these climates.....	1
Cholera belts, of flannel, when not part of the sea kit.....	2
Capes, waterproof (for 100 men).....	10

For India, a drill frock, drill trousers, and a white cap cover are issued.

SECTION IV.

ARTICLES OF CLOTHING.

1. *Underclothing*, viz., vests, drawers, shirts, stockings, flannel belts, etc.

The soldier, as a rule, wears as underclothing only a shirt and socks. He is obliged to have in his kit two shirts. There has been much discussion as to the respective merits of cotton and flannel. Almost all medical officers prefer the latter, but its cost, weight, difficulty of cleaning, and shrinking in washing, have been objections to its general adoption. General Sir A. Herbert solved the difficulty by issuing a shirt which is partly wool, partly cotton; it is lighter and cheaper than wool, as durable as cotton, and does not shrink in washing. It is of soft even texture, and weighs 19 ounces. Under the microscope, Dr. Parkes counted from 45 to 47 per cent. of wool.

In time of war, shirts may be partially cleaned in this way: The soldier should wear one and carry one; every night he should change; hang up the one he takes off to dry, and in the morning beat it out and shake it thoroughly. In this way much dirt is got rid of. He should then carry this shirt in his pack during the day, and substitute it for the other at night. If in addition great care is taken to have washing parades as often as possible, the difficulty of cleaning would be avoided.

For hot countries, the common English flannels are much too thick and irritating; flannel must be exceedingly fine, or what is perhaps better, merino hosiery, which contains from 20 to 50 per cent. of cotton, could be used. The best writers on the hygiene of the tropics (Chevers, Jeffreys, Moore) have all recommended flannel.

The soldier wears no drawers, but in reality it is just as important to cover the legs, thighs, and hips with flannel as the upper part of the body. Drawers folding well over the abdomen form, with the long shirt, a double fold of flannel over that important part, and the necessity of cholera belts or kummerbunds is avoided. Cholera belts are made of flannel, and fold twice over the abdomen.

The soldiers' socks are of worsted; they should be well shrunken before being fitted on. It has been proposed to divide the toes, but this seems an unnecessary refinement. It has been also proposed to do away with stockings altogether, but with the system of wearing shoes, it is difficult to keep the feet perfectly clean. The boots get impregnated with perspiration. Some of the German troops, instead of stockings, fold pieces of calico across

the foot when marching; when carefully done, this is comfortable, but not really better than a good sock kept clean.

2. *Outer Garments.*—The clothes worn by the different arms of the service and by different regiments in the same branch, are so numerous and diverse, that it is impossible to describe them. In many cases taste, or parade, or fantasy simply, has dictated the shape or the material. And diversities of this kind are especially noticeable in times of peace. When war comes with its rude touch, everything which is not useful disappears. What can be easiest borne, what gives the most comfort and the greatest protection, is soon found out. The arts of the tailor and the orders of the martinet are alike disregarded, and men instinctively return to what is at the same time most simple and most useful. It will be admitted that the soldier intended for war should be always dressed as if he were to be called upon the next moment to take the field. Everything should be as simple and effective as possible; utility, comfort, durability, and facility of repair, are the principles which should regulate all else. The dress should never be encumbered by a single ornament, or embarrassed by a single contrivance which has not its use. Elegant it may be, and should be, for the useful does not exclude, indeed often implies, the beautiful, but to the eye of the soldier it can be beautiful only when it is effective.[1]

Head-Dress.—The head-dress is used for protection against cold, wet, heat, and light. It must be comfortable; as light as is consistent with durability; not press on the head, and not to be too close to the hair; it should permit some movement of air over the head, and therefore openings, not admitting rain, must be made; it should present as little surface as possible to the wind, so that in rapid movements it may meet the least amount of resistance. In some cases it must be rendered strong for defence; but the conditions of modern war are rendering this less necessary.

As it is of great importance to reduce all the dress of the soldier to the smallest weight and bulk, it seems desirable to give only one head-dress, instead of two, as at present. Remembering the conditions of his life, his exposure and his night-work, the soldier's head-dress should be adapted for sleeping in as well as for common day-work. Another point was brought into notice by the Crimean war; in all articles of clothing, it much facilitates production, lessens expense, and aids distribution, if the different articles of clothing for an army are as much alike as possible; even for the infantry, it was found difficult to keep up the proper distribution of the different insignia of regiments.

Head-Dress of the Infantry.—The present head-dresses are the bear-skin caps for the Guards, a smaller and rather lower kind of seal-skin for Fusiliers, the Highland bonnets and shakoes for the Highland Regiments, and helmets for the Artillery, Engineers, and Line, and forage caps for all. The bear-skin weighs 37 ounces; the Infantry helmet, made of cork and cloth, 14¼ ounces. It is for the professional soldier to decide if the rapid movements and the necessity of cover in modern war are compatible with the retention of the bear-skin. If not, no one would wish to retain it on sanitary grounds; it is heavy, hot, gives little shelter from rain, and opposes a large surface to the wind.

The Glengarry Scotch cap, now adopted as the forage cap of the army, is very soft and comfortable, presses nowhere on the head, has sufficient height above the hair, and can be ventilated by openings if desired; it

[1] La tenue, dans laquelle le militaire est prêt à marcher à l'ennemi, est toujours belle.—Vaidy.

cannot be blown off; it can be carried at the top of the head when desired in hot weather, or pulled down completely over the forehead and ears in cold. Unfortunately, either to save cloth or from some idea of smartness, it is now being made so small that its advantages are imperilled, as it cannot be drawn down over the head.

Head-Dress of the Cavalry.—The Horse Artillery and Cavalry carry helmets and caps of different kinds.

The shape of the helmet in the Guards and heavy dragoons is excellent. It is not top-heavy; offers little surface to the wind; and has sufficient but not excessive height above the head. The material, however, is objectionable. The metal intended for defence makes the helmet very hot and heavy; and the helmet of the Cavalry of the Guard weighs 55 ounces avoir.; that of the Dragoon Guards, 39 ounces (in 1868). But as every ounce of unnecessary weight is additional unnecessary work thrown on the man and his horse, it is very questionable whether more is not lost than is gained by the great weight caused by the metal. Leather is now often substituted in some armies, where the cavalry helmets are being made extremely light.

The Lancer cap weighs 34½ ounces; the Hussar, 29¾ ounces. Both are dresses of fantasy. The Lancer cap, except for its weight, is the better of the two; is more comfortable; shades the eyes; throws off the rain better; and offers less resistance to moving air than the Hussar cap.

In Canada, a fur cap is used, with flaps for the ears and sides of the face and neck.

In India, many contrivances have been used. Up to the year 1842 little attention seems to have been paid to the head-dress of the infantry, and the men commonly wore their European forage caps. In 1842 Lord Hardinge issued an order, that white cotton covers should be worn over all caps; subsequently, a flap to fall down over the back of the neck was added. The effect of the cotton cover is to reduce the temperature of the air in the cap about 4° to 7° Fahr. Although a great improvement, it is not sufficient.

Bamboo wicker helmets, covered with cotton and provided with puggeries, are now used; they are light (13 oz.), durable, not easily put out of shape, and cheap. The rim is inclined, so as to protect from the level rays of the sun. The pith, or "Sola" hats, appear to be decidedly inferior to the wicker helmets; and men have had sunstroke while wearing them.

In the French infantry the shako is now made of leather and pasteboard, and is divested of all unnecessary ornament, so as to be as light as it can be. It comes well back on the head, being prolonged, as it were, over the occipital protuberance.

In Algeria, the Zouaves, Spahis, and Tirailleurs wear the red fez, covered with a turban of cotton. In Cochin-China, the French have adopted the bamboo wicker helmet of the English.

The natural hair of the head is a very great protection against heat. Various customs prevail in the East. Some nations shave the head, and wear a large turban; others, like the Burmese, wear the hair long, twist it into a knot at the top of the head, and face the sun with scarcely any turban. The Chinaman's tail is a mere mark of conquest. The European in India generally has the hair cut short, on account of cleanliness and dust. A small wet handkerchief, or piece of calico, carried in a cap with good ventilation, may be used with advantage; and especially in a hot land-wind cools the head greatly.

Coat, Tunic, Shell-Jacket, etc.—The varieties of the coat are numer-

ous in the army; and there are undress and stable suits of different kinds. The infantry now wear the tunic, which is a great improvement over the old cutaway coatee. It is still, however, too tight, and made too scanty over the hips and across the abdomen. A good tunic should have a low collar, and be loose round the neck. The *stock* is now abolished, a tongue of leather being substituted where the collar of the tunic is hooked in front. The tunic should also be loose over the shoulders (so as to allow the deltoid and latissimus the most unrestricted play),[1] and across the chest. It should come well across the abdomen, so as to guard it completely from cold and rain; descending loosely over the hips, it should fall as low over the thighs as is consistent with kneeling in rifle practice, *i.e.*, as low as it can fall without touching the ground. Looking not only to the comfort of the soldier, but to the work and force required of him, it is a great mistake to have the tunic otherwise than exceedingly loose. A loose tunic, a blouse in fact, is in reality a more soldier-like dress than the tight garment, which every one sees must press upon and hinder the rapid action of muscles. The tunic should be well provided with pockets, not only behind, but on the sides and in front; the pockets being internal, and made of a very strong lining. In time of war, a soldier has many things to carry; food, extra ammunition sometimes, all sorts of little comforts, which pack away easily in pockets. If the appearance is objected to, they need not be used in time of peace; but with a loose dress, they would not be seen.

A great improvement was made by General Herbert. The old shell-jacket was done away with, and a loose frock substituted.

In India the tunic is made loose, and of thin material.

Waistcoats.—No waistcoats are worn in the British army, but they ought to be introduced.[2] A long waistcoat with arms is one of the most useful of garments; it can be used without the tunic when the men are in barracks or on common drill. Put on under the tunic, it is one of the best protections against cold. At present the men are obliged to wear tight coats, and having nothing under them, line them with flannel and wadding. In winter and summer they often wear the same dress, although the oppression in the summer is very great. If the tunic were made very loose of some light material, and if a good short Jersey or Guernsey frock were allowed to be worn at the option of the men, the men would have cool dresses in summer, warm in winter, and the thin tunic would be more comfortable in the Mediterranean and subtropical stations.

Trousers.—Formerly the army wore breeches and leggings; but shortly before or during the Peninsular war trousers were introduced. The increased comfort to the soldier is said to have been remarkable; the trouser, indeed, protecting the leg quite down to the ankle, seems to be as good a dress as can be devised, if it is made on proper principles, viz., very loose over the hips and knees, and gathered in at the ankle, so that merely sufficient opening is left to pass the foot through. The much-laughed-at pegtop trousers seem to be, in fact, the proper shape. In this way the whole leg is protected, and the increased weight given by the part of the trousers below the knee is a matter of no consequence.

The trousers are supported either by braces or a belt. If the latter be used, it should be part of the trousers, should fit just over the hip, and

[1] This cannot occur if epaulets are worn; and it is to be hoped nothing will ever occur to bring in again the use of the so-called ornaments.

[2] A waistcoat was introduced some time ago, but has since been unfortunately withdrawn again.

not go round the waist. It must be tight, and has one disadvantage, which is that in great exertion the perspiration flowing down from above collects there, as the tight belt hinders its descent; also, if heavy articles are carried in the pocket, the weight may be too great for the belt. Braces seem, on the whole, the best.

Trousers should be made with large pockets, on the principle of giving the men as much convenience as possible of carrying articles in time of war.

In India, trousers are made in the same fashion as at home, but of drill or khakee cloth, or thin serge—an excellent material, especially for the northern stations.

Leggings and Gaiters.—Formerly long leggings reaching over the knees, and made of half-tanned leather, were used. They appear not to have been considered comfortable, and were discarded about sixty years ago. Short gaiters were subsequently used for some time, but were finally given up, and for several years nothing of the kind was worn. After the Crimean war Lord Herbert introduced for the infantry short leather leggings, 6 inches in height, and buttoning on the outside. These were not of good length or shape, and have now been superseded by leggings which come more up to the knee, and are much more serviceable.

In some of the French regiments a gaiter of half-dressed hide comes up to just below the knee; short calico or linen gaiters are worn by other corps; a flap comes forward over the instep. The calico gaiters have been much praised, but they soon get saturated with perspiration, thickened in ridges, and sometimes irritate the skin. On the other hand, leather gaiters, if not made of good leather, lose their suppleness, and press on the ankles and instep.

A great advantage of gaiters and leggings is, that at the end of a march they can be at once removed and cleaned; but, on the whole, if suitable leather could be fixed at the bottom of trousers, they might perhaps be abandoned.

Shoes and Boots.—In the action of walking the foot expands in length and breadth; in length often as much as $\frac{1}{10}$th, in breadth even more. In choosing shoes this must be attended to. The shoemaker measures when the person is sitting, and as a rule allows only $\frac{1}{24}$th increase for walking. Ankle boots, weighing 40 to 42 ounces, are now worn by the infantry: the cavalry have Wellingtons and jackboots. The jackboots of the Life Guards weigh (with spurs) 100 ounces avoir. Shoes cannot be worn without gaiters. Ankle boots are preferable; in the English army they are now made to lace, and are fitted with a good tongue. Great attention is now paid at Pimlico to the shape and make of the boot, and the principles laid down by Camper, Meyer, and others, are carefully attended to. There are eight sizes of length and four of breadth, making thirty-two sizes in all. The boots are made right and left. The heel is made very low and broad, so that the weight is not thrown on the toes, the gastrocnemii and solei can act, which they cannot do well with a high heel, and there is a good base for the column which forms the line from the centre of gravity, and the centre of gravity is kept low; the inner line of the boot is made straight, so as not to push outward the great toe in the least degree, and there is a bulging over the root of the great toe to allow easy play for the large joint. Across the tread and toes the foot is made very broad, so that the lateral expansion may not be impeded; the toes are broad. Great care is taken in the inspection of the boots, the order of inspection being—1st, The proof of the size, which is done by standard measure; 2d, The excel-

lence of the leather, which is judged of by inspection of each boot, and by selecting a certain number from each lot furnished by a contractor, and cutting them up; if anything wrong is found, the whole lot is rejected; 3d, The goodness of the sewing; there must be a certain number of stitches per inch (not less than eight for the upper leathers), a certain thickness of thread, and the thread must be well waxed. The giving up of boots is generally owing to the shoemaker using a large awl, and thin unwaxed thread, with as few stitches as possible; the work is thus easier to him, but the thread soon rots.

The Germans are now introducing a long boot, with a slit down the centre; it can be worn under the trousers, or at pleasure outside, as the slit opens, and can then be laced. A somewhat similar boot was invented by the late Major Sir W. Palliser.

Considering the great injury inflicted on the foot by tight and ill-made boots, by which the toes are often distorted and made to override, and the great toe is even dislocated and ankylosed, it is plain that the increased attention lately excited on this point is not unnecessary. The compression of children's feet by the tight leather shoes now made is extremely cruel and injurious. It may, indeed, be asserted that the child's foot would be better if left altogether unclothed, and certainly we see no feet so well modelled as the children of the poor, who run about shoeless. In the case of the soldier, too, who has in many campaigns been left shoeless, and has greatly suffered therefrom, it is a question whether he should not be trained to go barefooted. The feet soon get hard and callous to blows, and cleanliness is really promoted by having the feet uncovered, and by the frequent washings the practice renders necessary. After being unworn for some time, shoes that previously fitted will be found too small, on account of the greater expansion of the foot, and this is itself an argument against the shoe as commonly worn.

The sandal in all hot countries is much better than the shoe, and there is no reason why it should not be used in India for the English soldiers as it is by the native; the foot is cooler, and will be more frequently washed. For all native troops, negroes, etc., the sandal should be used, and the boot altogether avoided. In campaigns it is most important to have large stores of boots at various points, so that fresh boots may be frequently issued, and worn ones sent back for repair. Soldiers ought to be trained to repair their own boots.[1]

Great-coat and Cloak.—In the cavalry, cloaks, with capes which can be detached, are carried. They are large, so as to cover a good deal of the horse, and are made of good cloth; the weight is about 5 lb to 6 lb for the cloak, and 2½ lb to 3 lb for the cape. The infantry wear great-coats weighing from 5 lb to 6 lb.[2] They are now made of extremely good cloth, are double-breasted, and are as long as can be managed. They are not provided with pockets at the back, which is a serious omission, and they also should have loops, so that the flaps may be turned back if desired.

[1] It may be worth while to give a receipt for making boots impermeable to wet. Dr. Parkes tried the following, and found it effectual: Take half a pound of shoemaker's dubbing, half a pint of linseed oil, half a pint of solution of india-rubber (price 3s. per gallon). Dissolve with gentle heat (it is very inflammable), and rub on the boots. This will last for five or six months; but it is well to renew it every three months. At a small expense the boots of a whole regiment could be thus made impermeable to wet. Army Circular, clause 66, 1875, directs—(1) That boots are to be blackened with three coats of ordinary blacking, instead of other substances.

[2] The following are the exact weights of three—one large size, one medium, and one small; the weights were 6 lb 3 ounces, 5 lb 9 ounces, and 5 lb 8 ounces.

They are too heavy, and absorb a great deal of wet, so that they dry slowly. General Eyre's Committee on Equipments recommended a lighter great-coat, and in addition a good waterproof cape. The suggestion seems to be a very good one.[1] A hood might also be added with advantage. In countries with cold winds they are a great comfort. Or the Russian bash-lik might be introduced ; it is a most useful covering for cold and windy countries.

The great-coat is perhaps the most important article of dress for the soldier. With a good great-coat, Robert Jackson thought it might be possible to do away with the blanket in war, and if india-rubber sheets were used this is perhaps possible. In the Italian war of 1859, the French troops left their tunics at home, and campaigned in their great-coats, which were worn open on the march.[2]

In countries liable to great vicissitudes of temperature, and to sudden cold winds, as the hilly parts of Greece, Turkey, Afghanistan, etc., a loose, warm cloak, which can be worn open or folded, is used by the inhabitants, and should be imitated in campaigns. It is worthy of remark, that in most of these countries, though the sun may be extremely hot, the clothes are very warm.

In very cold countries, sheep-skin and buffalo-hide coats, especially the former, are very useful. No wind can blow through them ; in the coldest night of their rigorous winter the Anatolian shepherds lie out in their sheepskin coat and hood without injury, though unprotected men are frozen to death. In Bulgaria, the Crimea, and other countries exposed to the pitiless winds from Siberia, and the steppes of Tartary, nothing can be better than coats like these.[3]

SECTION V.

WEIGHTS OF THE ARTICLES OF DRESS AND OF THE ACCOUTREMENTS, AND ON THE MODES OF CARRYING THE WEIGHTS.

The following tables give the weights of all the articles used by a Heavy Cavalry Regiment, an Hussar Regiment, and the Infantry of the Line. The weights carried by the Artillery are much the same as those of the Cavalry. The weights of the helmets and jackboots of the Life and Horse Guards have been already mentioned. The cuirass weighs 10 lb 12 oz. ; it rests a little on the sacrum and hip, and in that way is more easily borne by the man. With these exceptions, the weights may be considered nearly the same as those of the heavy dragoons. The uniform and equipment of the Guards and Cavalry are at present under consideration, and may be changed.

[1] Para. 47, sect. viii., Regulations for Clothing, directs the issue of a waterproof coat, leggings, wrappers, sou'wester caps, etc., for certain duties.

[2] Cloth may be made waterproof by the following simple plan :—Make a weak solution of glue, and while it is hot add alum in the proportion of one ounce to two quarts; as soon as the alum is dissolved, and while the solution is hot, brush it well over the surface of the cloth, and then dry. It is said that the addition of two drachms of sulphate of copper is an improvement.

[3] Sheep-skin bags with the wool inside were much used by the French troops during the defence of Paris, in the winter of 1870–71.

Cavalry.

The weight of the accoutrements and equipment is in great part carried by the horse. The cloak, when not worn, is carried in a roll over the shoulder, or sometimes round the neck, or in front on the horse.

Private in 6th Dragoon Guards.—Weights in Marching Order (January, 1872).

Articles.	lb.	oz.
Carbine	6	8
Sword-belt and sword	5	8
Pouch-belt and pouch	1	8
Cloak and cape	10	8
Valise completely packed	15	0
Saddle complete	47	8
Sheepskin, corn-sack, and nose-bag	8	8
Man's clothing (which includes a complete set of underclothing, helmet without plume, tunics, pants, haversack, gauntlets, knee-boots, and spurs)	17	0
Blanket	4	4
Heel Ropes	1	8
" Pegs	2	2
Shackles	0	10
Collar Shank	0	13
Wellington boots and spurs	2	10
	123	15
Average weight of man (naked)	161	0
Total	284	15

Or 20 stone and 5 lb (nearly).

Weights of Men's Clothes, Necessaries, etc., 10th Royal Hussars (1869).[1]

No.	Articles.	lb.	oz.
1	Tunic	3	0
1	Busby, plume, and lines	1	13¾
1	Pair leather overalls and straps	3	6
1	Pair cloth do. do.	2	7½
1	Stable-jacket	1	15½
1	Forage-cap	0	5
1	Valise	2	7
1	Cloak, 5 lb 8½ oz.; cape, 2 lb 6 oz.	7	14½
1	Pair boots	3	0¼
1	" spurs	0	5¼
1	" highlows	3	8
1	Stable-bag	0	6
1	Pair braces	0	3¾
1	Button-brush	0	1½
1	Cloth "	0	3½
1	Hair "	0	2¾
1	Brass "	0	2¾
1	Lace "	0	1
1	Shaving "	0	1¼
2	Shoe brushes	0	7½
1	Tin blacking	0	4½
1	Hair-comb	0	0½
2	Pairs drawers, each 13¾ oz.	1	11½
2	Pairs gloves, each 7¼ oz.	0	14½
Or, 2	Pairs cotton socks, each sock 2½ oz.	0	9
4	Brass paste	0	3½
1	Hold-all	0	4
1	Horse-rubber	0	11
1	Knife, fork, and spoon	0	4½
1	Pipeclay and sponge	0	2
1	Razor	0	2½
3	Shirts, each 14½ oz.	2	11½
1	Button brass	0	1¾
1	Stock	0	1½
2	Towels, 7¾ oz. each	0	15½
1	Stable trousers	1	5
2	Flannel jackets, each 11 oz.	1	6
1	Oil tin	0	2½
1	Pair foot-straps	0	0½
1	Mess-tin and strap	1	1½
1	Account-book	0	1½
		45	3½

[1] Since this date, the only change is the substitution of long boots for booted overalls; but it is uncertain if this change will be permanent.

Weights of Saddlery, 10th Royal Hussars.

Articles.	lb.	oz.
Saddle-tree	6	5½
" seat	1	6½
Pair flaps	2	8½
" panels	4	6½
Girth-tub	0	6½
Girth-leathers	1	1½
Stirrup-irons	1	11½
" leathers	1	3½
Crupper	0	14½
Breastplate	1	4¼
Surcingle	0	15
Set of baggage-straps	0	9¼
" cloak-straps	0	9½
Pair wallets	1	14½
Pair shoe-cases and straps	1	4
4 horse-shoes and nails	4	9
New carbine bucket	2	13½
Bridle-bit and head-stall	2	2
Bridoon-bit and reins	1	2
Curb-chain	0	3¾
Bit-reins	0	10½
Head-collar	1	11½
Collar-chain	1	12½
Sheepskin	4	4
Shabraque	4	6½
Numnah	2	11¼

Articles.	lb.	oz.
Corn-sack	1	11¼
Nose-bag	1	1½
Horse-brush	0	11
Curry-comb	0	11
Sponge	0	2
Hoof-picker	0	1¾
Scissors	0	3½
Horse-log	1	3¼
Haversack	0	9
Carbine	6	9
Pouch-belt, 11¼ oz. Pouch 12½ oz. 20 rounds ammunition, 32½ oz.	3	8¼
Wrist-belt, etc., 1 lb 1 oz. Sabretash and slings, 1 lb 5½ oz. Sword, 4 lb 10 oz.	7	0½
	76	7¾
Weight of equipments,	121	11¼
Total weight of Hussar[1] with all his equipments	259 or 18½ st.	6¼

Infantry.

The articles of the infantry soldiers' kit have been already noted. The kit is divided into the service and the surplus kit, the latter being always carried for, and not by, the man. The service kit consists of the clothes he wears, and of some duplicate articles and other necessaries.

These articles consist of one flannel shirt (19 ounces), pair of socks (5 oz.), pair of trousers (23 or 32 oz., according to kind), pair of boots (42 oz.), towel (8 oz.), hold-all, and knife, fork, and spoon (2½ oz.), 2 brushes (6 oz.), tin of blacking (6½ oz.), forage cap (4 oz.).

The following table gives a fairly correct statement of the weights of the kit and equipment:—

[1] Average weight and height of the men in these two cavalry regiments—

	Height. ft.	in.	Weight (naked). lb.	oz.
6th Dragoon Guards	5	9⅜	161	0
10th Hussars	5	7¾	137	11

	Average weight. lb.	oz.
Weight of clothes on person, including helmet, winter trousers, and leggings	10	0
Personal necessaries, viz., service kit in valise	7	3
Great-coat	5	8
Valise equipment for carrying necessaries, great-coat, and armament, viz., valise, two pouches, ball-bag, suspenders, waist-belt, frog, coat-straps	5	10
Haversack	0	8
Canteen	1	9
Armament, viz., rifle and sling (9 lb 8 oz.), bayonet (1 lb), ammunition (60 rounds, 6 lb weight = 1 lb for 10 rounds nearly)	16	8
Water-bottle (new pattern) and water	2	9
	49	7

In war, food and a blanket would be also carried, adding from 6 to 8 lb to the weight. By omitting 40 rounds of ammunition and one pouch, the weight of the peace equipment is lessened to 40 lb; and if the canteen were only carried when it was wanted, the weight would be under 39 lb. If the great-coat with the cape could be reduced to 5 lb, and the summer trousers and the boots were left out of the valise, the weight would be reduced below 35 lb, and still the soldier would have really everything necessary for his comfort.

Some experienced officers, however, consider it essential that the second pair of boots should be always carried by the soldier. No doubt a man should have a second pair of boots, and there may be circumstances in periods of peace when he might desire to have them with him; but surely there is no necessity for him to carry, as he does now, even if he only goes on guard on a fine day, a pair of boots which he never puts on. It might be left to his discretion to carry his extra boots, and it is pretty certain he will take them when they add to his comfort. So also with the second pair of trousers; why should they be constantly carried when they are scarcely ever wanted?

In time of war, it is most important to have the soldier as little weighted as possible. The long and rapid marches which have so often decided wars have never been made by heavily laden men. The health also suffers. It is of national importance that the soldier should be as healthy and as efficient as possible, as the fate of a nation may be staked on the prowess of its army.

The line which the weight of his necessaries should not exceed should be drawn with the utmost care; if his health suffers more by carrying some extra pounds of weight than it benefits by the comfort the articles give, why load him to his certain loss? The overdoing the necessaries of the soldier has always been a fault in our army; Robert Jackson noticed it seventy years ago. "It is a mistake," he says, "to multiply the equipment of the soldier with a view of adding to his comfort."

There are certain articles of material comfort to a man on service in a cold or wet country, and some alteration in the present arrangement would be desirable. Dr. Parkes proposed some slight changes. The great-coat, blanket, and a waterproof sheet (or portion of a shelter tent), to keep both the coat and blanket and the man himself dry, are articles of the utmost importance; there is scarcely anything that a soldier might not dispense with sooner than these. But their weight is considerable, and it is neces-

sary to sacrifice something else to secure them. The second pair of trousers is clearly unnecessary, and if he started with a thoroughly good pair of boots made waterproof, as can be easily done, and had a cheap loose shoe which he might put on after a fatiguing march, and if proper transport were provided for due renewal, the second pair of boots might be left out. A spare shirt, towel, socks, comb, a small hold-all, and a clasp-knife and spoon, would comprise all that would be necessary, in addition to his haversack, water-bottle, and provisions. The forage cap with waterproof cover should be substituted for the shako.

If such a plan were followed the weight of such a war equipment would be as follows:— [1]

	lb. avoir.	oz.
Clothes on person	10	0
Service kit in valise, viz., shirt (19 oz.), towel (8 oz.), soap (2 oz.), 1 comb (½ oz.), hold-all (3 oz.), socks (5 oz.), shoes (16 oz.)	3	1
Great-coat	4	0
Waterproof sheet (with appliances for tentage)	4	0
Blanket	4	0
Haversack and three days' provisions	6	0
Water-bottle and 20 fl. oz. of water	2	2
Canteen	1	9
Valise equipment	5	10
Armament (with sixty rounds)	16	8
	56	14

On ordinary occasions in war, as he would only carry one day's provisions and 40 rounds of ammunition, the weight would only be 52 lb. While he would be more comfortably provided, he would be less weighted than with the present system, and would be able, if it were required, to carry entrenching tools.

The valise equipment proposed by General Eyre's Committee, and now adopted for the army, possesses great facilities for carrying these articles, as will be presently noticed.

This committee also recommended that, instead of the squad-bag for 25 men, each man shall have a separate canvas bag for his surplus kit, as is now provided on board ship. In time of peace this would be carried for him, as the squad-bag is at present; in time of war it would be left at home.

It is of great moment to give each man a bag for surplus kit to himself. It encourages the men to take care of their things, and enables them to pack them comfortably. Each man is now supplied with a kit-bag.

It may be interesting to give the weights of the various articles carried by the infantry soldier of the French, Prussian, and Russian armies.

[1] The weight of the clothing, equipment, and kit of the Army Hospital Corps is as follows:—

	lb.	oz.
Clothes on the person, including helmet and leggings	10	9
Great-coat and cape	5	13
Extra kit and small articles	8	2
Valise with straps, belt, mess-tin, haversack, and black bag	8	1
Water-bottle (new pattern) with water	2	9
Field companion, complete	9	13
Water-bottle for ditto, with water	5	12
Total	50	11

Equipment of the French Infantry Soldier (*Morache*, 1874).

A. Clothing, etc. Articles.	Weight in lb avoir.	oz.
Shako	0	15¼
Great-coat	4	6½
Epaulettes	0	6¼
Shirt	1	0¾
Neckcloth	0	2¼
Braces	0	2½
Trousers	1	8¾
Drawers	0	10
Shoes	1	15½
Leather gaiters	0	11¾
Pocket handkerchief	0	2½
Knife	0	1½
Spoon	0	1
Total clothing, etc.	12	4¾
B. Equipment and Armament.		
Rifle (pattern of 1866)[1]	8	12¾
Strap for do	0	3½
Cartridge pouch, Belt and accessories, Sword-bayonet,	4	11¾
2 Loose cartridges	0	2¼
2 Packets of cartridges in pouch	1	5
Total equipment	15	3¼
C. Pack.		
I. Knapsack, empty	5	7
II. In pack :—		
2 Shirts	2	1½
1 Pair drawers	0	10
2 Pairs linen gaiters	0	5¼
1 Night-cap	0	1¾
1 Pocket handkerchief	0	2½
1 Pair shoes	1	15¾
1 Pair trousers	1	8¾
Hold-all complete	1	10½
2 Pairs gloves	0	3
8 Packets cartridges	5	1
Small book	0	1¼
Jersey	2	3¼
Tunic	3	15½
Forage-cap	0	4½
Small bag	0	5¾
III. Camp-equipage :—		
Tent (now omitted)	2	12½
Accessories	1	3¾
Blanket	3	8½
Cooking-pot	3	3
Mess-tin	0	14
Water-bottle, empty	0	13¾
IV. Four days' provisions, but only two days' of salt meat or bacon[2]	6	7½
Total	45	0¼
Grand total	72	8¼

The German infantry soldier carries the following weights :—[3]

Clothing on the person (with gloves), not including helmet	10	12½
Armament and equipment (including helmet, water-bottle (full), coffee-mill, and trenching tools)	31	5
Pack, with extra kit, etc., and reserve ammunition	19	13½
Great-coat and straps	5	11
Rations	7	3½
Total	74	13½

Some of the articles are not always carried by the same man, such as the hatchet, spade, and coffee-mill, so that the weight may be lessened to

[1] This has been recently altered to the Gras rifle, but apparently without change of weight.

[2] To this must be added for water in the water-bottle, 2 lb 3¼ oz. and at least 1 lb 2 oz. if the tent be damp, making a total of nearly 76 lb, but the *tent* is now omitted.

[3] Roth and Lex, op. cit., Bd. iii. (1877), p. 110.

66 lb—average weight carried, 66 lb to 71 lb. The shako of the riflemen and sharpshooters is about 3½ oz. lighter than the infantry helmet. The Mauser rifle weighs 10 lb, and the bayonet 1 lb 8½ oz.

The Russian soldier carries 70½lb, the Austrian 60 lb, and the Italian 75 lb ; the mean of European armies being 66 lb.

The mean weight of the rifles carried by European infantry is 9 lb 6 oz. ; of the bayonet, 1 lb 2½ oz. ; and of each cartridge, 1⅓ oz.

SECTION VI.

CARRIAGE OF THE NECESSARIES AND ARMAMENT.

The equipment of the cavalry soldier is in great part carried by the horse ; but apparently the mode in which the cavalry valise is arranged is not comfortable to the men. The total weight carried by the horse appears also to be large. A soldier has personal and horse equipments equal to nearly his own weight. Without pronouncing on the necessity of this, it is a fact that in light-cavalry regiments the horse now carries nearly 19 stone weight, although the rider is on average under 10 stone.

In the case of the infantry soldier, who carries the weights himself, the greatest care is necessary to place them in the manner least likely to detract from his efficiency or to injure his health. If it were possible to let a man, in European countries, carry nothing but his armament and water-bottle, as in India, much more work would be got out of him, longer marches would be made, and he would show greater endurance on the day of action. But such an arrangement is impossible, as transport could not be provided, and the alternative of leaving a man without his necessaries is not to be thought of. But it cannot be too strongly impressed on all commanding officers, that every ounce of weight saved is a gain in efficiency. The Prussians, in the war of 1866, obtained wagons, whenever they could, to carry the knapsacks, and the comparison between the condition of the men thus relieved and those who could not be so, was striking.[1] A change of opinion also must be brought about in the army on a very material point. Some officers believe that, as the men must carry weights in war, they ought to carry them on all occasions during peace, so that the men may be accustomed to them ; and they attempt to strengthen their position by referring to the custom of the Romans, who exercised their men in peace with heavier weapons than those used in war. But this example is not applicable. A man should be exercised in the highest degree in any way which may develop his muscles and improve the circulation through his lungs and heart. Any amount of muscular exertion (within, of course, reasonable limits), any degree of practice with weapons, must be good as long as his body is unshackled ; but if he is loaded with weights, and especially if the carriage of the weights at all impedes the action of the lungs and heart, then the very exertion which in other circumstances would benefit him must do him

[1] See Mr. Bostock's able Report in the Army Medical Reports, vol. vii., p. 359.

Dr. Parkes quotes a letter from a Prussian officer, high in rank, and certain to know the fact, stating that the difference in the health of the Prussian soldiers who carried the knapsacks in the Bohemian marches in 1866, and those who did not, was remarkable. The men who had not carried their packs, though they had not had the comfort of their necessaries, were fresh and vigorous and in high spirits ; those who had carried them, on the other hand, were comparatively worn and exhausted. And this was with the best military knapsack then known.

harm. The soldier must carry weights sometimes, but it should be a rule not to carry them when he has no immediate need of the various articles. The aim should be the cultivation of the breathing power of his lungs and the power of his muscles to an extent which will enable him to bear his weights, at those times when he must carry them, more easily than if, on a false notion of accustoming him to them, he had been obliged to wear them on all possible occasions.

Sufficient practice with the weights to enable a man to dispose them comfortably, and to make him familiar with them, should of course be given; but a very short teaching will suffice for this.

The weights which an infantry soldier has to carry have already been stated; the mode of disposing of them has now to be considered.

Weights are most easily borne when the following points are attended to:—

1. They must lie as near the centre of gravity as possible. In the upright position the centre of gravity is between the pelvis and the centre of the body, usually midway between the umbilicus and pubis, but varying of course with the position of the body; a line prolonged to the ground passes through the astragalus just in the front of the os calcis. Hence weights carried on the head or top of the shoulder, or which can be thrown toward the centre of the hip bones, are carried most easily, being directly over the line of the centre of gravity. When a weight is carried away from this line the centre of gravity is displaced, and, in proportion to the added weight, occupies a point more or less distant from the usual site; until, perhaps, it is so far removed from this that a line prolonged downward falls beyond the feet; the man then falls, unless, by bending his body and bringing the added weight nearer the centre, he keep the line well within the space which his feet cover.

In the distribution of weights, then, the first rule is to keep the weight nearer to the centre; hence the old mode of carrying the soldier's great-coat, viz., on the back of the knapsack, is a mistake, as it puts on weight at the greatest possible distance from the centre of gravity.

2. The weights must in no case compress the lungs, or in any way interfere with the respiratory movements, or the elimination of carbonic acid, or hinder the transmission of blood through the lungs, or render difficult the action of the heart.

3. No important muscles, vessels, or nerves should be pressed upon. This is self-evident; an example may be taken from the old Regulation pack, the arm-straps of which so pressed on the axillary nerves and veins as to cause numbness, and often swelling of the hands, which has been known to last for twenty-five hours.

4. The weights should be distributed as much as possible over several parts of the body.

If we consider the means made use of by those who carry great weight, we find the following points selected for bearing them:—

1. The top of the head. The cause of this is obvious; the weight is completely in the line of centre of gravity, and in movement is kept balanced over it. Of course, however, very great weights cannot be carried in this way.

2. The tops of the scapulæ, just over the supra-spinous fossa and ridge. At this point the weight is well over the centre of gravity, and it is also diffused over a large surface of the ribs by the pressure on the scapula.

3. The hip bones and sacrum. Here, also, the weight is near the

centre of gravity, and is borne by the strong bony arch of the hips, the strongest part of the body.[1]

In addition, great use is always made by those who carry great weights of the system of balance. The packman of England used to carry from 40 to even 60 lb easily thirty miles a day by taking the top of the scapula for the fixed point, and having half the weight in front of the chest and half behind. In this way he still brought the weight over the centre of gravity. The same point, and an analogous system of balance, is used by the milk-maid, who can carry more weight for a greater distance than the strongest guardsman equipped with the old military accoutrements and pack.

These points must guide us in arranging the weights carried by the soldier. The weight on the head is, of course, out of the question. We have, then, the scapulæ, the hip, and the principle of balance, to take into consideration.

In our army the carriage of the kit and ammunition has always been felt to be a difficulty, and many have been the changes in the infantry knapsacks since the close of the Peninsular war. The method of carriage which was formerly in use, though better than some of the older plans, had grave defects, and it has now been superseded by the new equipment.[2]

The new infantry equipment, proposed by a War Office Committee, appointed by Lord de Grey in 1864, and of which General Henry Eyre was the president, was devised for the purpose of enabling the infantry soldier to carry his weights with greater comfort (and, therefore, to enable him to march farther), and especially to do away with any chance of injuring his heart and lungs.[3] This committee presented four reports to the War Office.[4]

Considerable difficulty was found in fixing on the best equipment; in addition to all the points already noted, simplicity and durability, and as much freedom from accidental breakage as could be insured, were essential; facility of removal and readjustment for emergencies, adaptation for various conditions of service, and suitableness for military exercises, had all to be considered. After passing in review all the known plans, and experimenting on a large scale, the committee at last recommended a plan which, after an extended trial in many regiments, and being submitted to the opinions of many officers, was finally authorized and issued in place of the old pattern.

[1] The girls engaged in some of the works in Cornwall carry immense bags or hampers of sand up steep hills by resting the lower part of the sack on the hip and sacrum, and the upper part on the scapula. It is the same position as that taken by the Turkish porters, who will carry 600 and 800 lb some distance; they also sometimes have a band round the forehead fastened to the top of the weight.

[2] In the former editions descriptions were given of the obsolete Regulation equipment, and of various other plans. But it has been thought unnecessary to repeat these.

[3] In the chapter on HOME SERVICE are given the facts about the amount of heart and vessel disease in the army. It appears to be very large, and to be attributable, in part at any rate, to exercise under unfavorable conditions. It is not confined to the infantry, but is common to all branches, and perhaps the disease of the vessels is even greater in degree in the cavalry and artillery. Professor Maclean, C.B., called the attention of the authorities to this matter in a striking lecture delivered at the Royal United Service Institution, and published in the Journal of the Institution, vol. viii., and from which extracts were given in former editions. The army is greatly indebted to Dr. Maclean for his clear exposition on this point. The first Report of the Committee on Knapsacks contains the evidence to that date.

[4] Reports of the Committee appointed to Inquire into the Effect on Health of the present System of carrying the Accoutrements, Ammunition, and Kit of Infantry Soldiers: First Report, 1865; Second Report, 1867; Third and Fourth Reports, 1868.

The new equipment is essentially based on the yoke valise plan of the late Colonel Sir Thomas Troubridge, C.B., who had been for many years experimenting on this subject;[1] but it is greatly altered in details in order to avoid the use of copper or iron rods. The two great principles are to use the scapulæ and the sacrum in about equal proportion as carriers of the weight, and to place the weights as near to the body as possible, and, as far as could be done, in front as well as behind, so as to avoid the displacement of the centre of gravity. The great advantage of using the sacrum as one of the points of support has been very apparent in the trials of the valise plan. In that way only can the chest be thoroughly relieved; a very great weight can be carried without injury if it is necessary, and apart from that a mechanical advantage of no small moment has been obtained. For the effect of placing the kit and ammunition low down is to free the large muscles of the shoulder and back from the impediment which hinders their action when a knapsack of any kind is carried in its usual place; the bayonet exercise can therefore be much better performed; but more than this, the soldier engaged in a personal struggle is in far better position than with a knapsack on the upper part of the back; for in the latter case, the centre of gravity being displaced (raised and carried backwards), the man has already a tendency to fall back which tells seriously against him. In the new equipment, on the contrary, the great weights being all below the centre of gravity, rather tend to keep a man steadier and firmer on his legs than otherwise.

In order to gain these advantages, and also to lessen the weight of the equipment, the framed knapsack was abandoned, and a bag or valise substituted, which is large enough to carry the service kit and some provisions. The total weight of the whole equipment, as intended for active service, is 5 lb 8 oz.

In the peace equipment there is a single pouch in front, which can be shifted to one side so as to allow the waist-belt to be opened. The straps running up over the shoulder from the rings are made broad on the scapulæ, they cross on the back like a common pair of braces, and then catching the top of the valise on the other side by a buckle, run under the arm to the ring on the opposite side from which they started. From this ring a strap runs to the bottom of the valise which is placed resting on the sacrum; by this arrangement the weight of the valise is thrown partly on the shoulder, partly on the sacrum, and is also thrown forward in a line with the centre of gravity. From the ring another strap runs to the waist-belt and supports the ammunition, which thus balances in part the weight behind.

In full service order two pouches are carried in front, each holding 20 rounds; there is also a ball-bag, intended to hold loose cartridges for rapid firing, in which, if there be necessity, 20 or even 30 cartridges can be put. There is provision in the valise for twenty more.

The greatcoat is placed above the valise, and being soft, gives no obstruction to the action of the muscles of the shoulder.

The canteen can be carried over the greatcoat; but many officers prefer carrying it on the valise, where there are two loops intended for it.

This equipment is very easy, and leaves the chest perfectly free; it is simple both in principle and construction, and affords many facilities for carriage of articles, such as the haversack, the water-bottle, blanket, etc.,

[1] Sir T. Troubridge's equipment will be found described and figured in the 2d edition of this work. He had made experiments on this subject for more than fifteen years.

which prove useful on service. It is of more importance to note here, that it certainly answers all medical requirements; and as it leaves the man very free and unencumbered in his movements, it does away entirely with the stiff unmilitary appearance produced by the old plan.

There seems only one sanitary point which has been urged against this equipment, and that is, that a good deal of the back is covered, and that perspiration collects under the valise. Whatever equipment be used, there must be retention of perspiration under the covered parts: this is inevitable, and is produced by any knapsack. The valise equipment is no exception to the rule, but it is singular how little perspiration really collects under the valise if the man knows how to manage it. By allowing the top of the valise to fall back half an inch, a space is left between the greater part of the valise and back, which allows evaporation, and the latter are kept cool. On the march also, when the waist-belt is unbuckled, both the valise and great-coat hang loosely and away from the body, and evaporation goes on.

The principle of the valise equipment will probably always be maintained, although some details may be altered. The "magazine arrangements," invented by Brigade-Surgeon W. S. Oliver, A.M.D., have been under trial some time, and have been very favorably reported upon. They appear to be even easier than the valise equipment, and are less complicated in their fittings: they provide for the carriage of more ammunition, and leave the back freer for transpiration. There is also a light waterproof cape, which can be used as a sheet or portion of a shelter tent.

SECTION VII.

WORK OF THE SOLDIER.

The kind and amount of work in the different arms of the service is so different that it is impossible to bring it under one general description. In the artillery, cleaning horses, gun carriages, and accoutrements, and gun drill: in the cavalry, cleaning of horses, accoutrements, and drill with the special arm: in the infantry, drill, and barrack and fatigue duties, and the cleaning of arms and accoutrements, are all kinds of work, the amount of which is not easy to estimate.

Much of the work of the artillery and cavalry is highly beneficial to them, and the fine well-developed muscles show that all parts of the body are properly exercised. Some of the work (such as gun drill or sword exercise) is hard, and even violent, and the great amount of aneurism in both bodies of men, as well as in the infantry, has led to the idea that the exercise is either too severe, or is performed under unfavorable conditions, such as heavy equipments or too tight-fitting clothes. Although violent while it lasts, it seems questionable whether the work is so severe as that which many mechanics undergo without injury: it may, however, be more sudden and rapid, and the heart may be brought into more violent action. The conditions under which the work is done are certainly less favorable than in the case of the mechanic, who is never embarrassed by weights or tight clothes.

[1] Reference may be made to the 2d edition of this work for figures and descriptions of the continental packs and to the Reports of the War Office Committee on Knapsacks and Accoutrements for fuller details than can be given here. For the present system, see Valise Equipment for Infantry Regiments, Instructions for Fitting the, 1876.

In the infantry the amount of aneurism is slightly below that of the other arms, but not much so. The hard work in the infantry is the running drill when the weights are carried, bayonet exercise, and long marches; but though severe, it is not so excessive as to lead us to think it would do injury to strong men if all circumstances were favorable.

During war the amount of labor undergone is sometimes excessive, as will be clear from what is said in the next section, and in the rapid campaigns of modern times, very young and weakly men are soon exhausted.

A soldier requires to be trained for the ordeal of active service, and this is now done in our army by a series of gymnastic exercises and systematic marches, intended to develop every muscle, to make the artillery or the cavalry man able to vault on his horse, and the foot soldier to run and to escalade, and to march great distances without fatigue.

Gymnastic Exercises.—All military nations have used in their armies a system of athletic exercises. The Greeks commenced such exercises when the increase of cities had given rise to a certain amount of sedentary life. The Romans began to use athletic training in the early days of the Republic, entirely with a view to military efficiency. The exercises were continuous, and were not alternated with periods of complete idleness.

The officers exercised with the men. At a later day, we are told that Marius never missed a single day at the Campus Martius; and Pompey is said by Sallust to have been able at fifty-eight years of age to run, jump, and carry a load as well as the most robust soldier in his army.

Swimming was especially taught by the Romans, and so essential were the gymnastic exercises deemed that, to express that a man was completely ignorant, it was said "he knew neither how to read nor swim." The gymnastic exercises were the last of the old customs which disappeared before the increasing luxury of the latter empire.

In the feudal times the practice of the weapons was the best gymnastic exercise; every peasant in England was obliged to practise with the bow; the noblemen underwent an enormous amount of exercise, both with and without arms, and on foot and horseback.

After the invention of gunpowder the qualities of strength and agility became of less importance for the soldier, and athletic training was discontinued everywhere. But within the last few years the changing conditions of modern warfare have again demanded from the soldier a degree of endurance and of rapidity of movement which the wars of the eighteenth century did not require. And the population generally of this country have of late years become alive to the necessity of compensating, by some artificial system of muscular exercise, the sedentary life which so many lead.

In our own time, the first regular gymnasium appears to have been established at Schwefental, in Saxony, by Saltzmann, with a view of giving health to the body, strengthening certain muscles, and remedying deformities. About sixty years ago Ling also commenced in Sweden the system of movements which have made his name so celebrated. Switzerland, Spain, and France followed, and of late years in Germany many gymnastic societies (Turner-Verein) have been founded in almost all the great cities, and the literature of gymnasticism is now a large one. In our own country, the outdoor and vigorous life led by the richer classes, and by many working men, rendered this movement less necessary, but of late years societies have been formed, gymnasia established, and athletic sports encouraged in many places.

Among armies, the Swedish and Prussian were the first to attempt the

physical training of their soldiers. France followed in 1845, and ever since a complete system of gymnastic instruction has been carried on in the French army, and a military gymnastic-school exists at Vincennes, where instructors for the army are taught.

In the English army this matter attracted less attention until after the Crimean war, when the establishment of gymnasia as a means of training and recreation were among some of the many reforms projected by Lord Herbert. In 1859 General Hamilton and Sir G. Logan, lately Director-General of the Army Medical Department, were sent over to inspect the systems in use on the Continent, and presented a very interesting Report, which was subsequently published. A grant of money was immediately taken for a gymnasium at Aldershot, and this has now been in operation for several years, under the direction of Colonel Hammersley, with most satisfactory results. Gymnasia are now ordered to be built at all the large stations, and a complete code of instructions, drawn up by Mr. Maclaren of Oxford, is published by authority.[1]

The instructions have two great objects—1*st*, To assist the physical development of the recruit; 2*d*, To strengthen and render supple the frame of the trained soldier. Every recruit is now ordered to have three months' gymnastic training during (or, if judged expedient by a medical officer, in lieu of part of) his ordinary drill. Two months are given before he commences rifle practice, and one month afterward. This training is superintended by a medical officer, who will be responsible that it is done properly, and who will have the power to continue the exercises beyond the prescribed time, if he deems it necessary. The exercise for the recruit is to last only one hour a day, and in addition he will have from two to three hours of ordinary drill.

The trained infantry soldier is ordered to go through a gymnastic course of three months' duration every year, one hour being given every other day. The cavalry soldier is to be taught fencing and sword exercise in lieu of gymnastics.

The "Code of Instructions" drawn up by Mr. Maclaren consists of two parts, elementary and advanced exercises. The exercises have been arranged with very great care, and present a progressive course of the most useful kind. The early exercise commences with walking and running; leaping, with and without the pole, follows; and then the exercises with apparatus commence, the order being the horizontal beam, the vaulting bar, and the vaulting horse. All these are called exercises of progression. The elementary exercises follow, viz., with the parallel bars, the pair of rings, the row of rings, the elastic ladder, the horizontal bar, the bridge ladder, and the ladder plank. Then follow the advanced exercises of climbing on the slanting and vertical pole, the slanting and vertical rope, and the knotted rope.

Finally, the most advanced exercises consist of escalading, first against a wall, and then against a prepared building.

In the French army swimming and singing are also taught. Both are very useful; the singing is encouraged, not as a matter of amusement (though it is very useful in this way), but as a means of improving the lungs.

Swimming should be considered an essential part of the soldier's edu-

[1] Gymnastic Exercises, etc., 1877. Mr. Maclaren has also published two other works of great utility; a System of Training and Physical Education. This last work should be in the hands of every one.

cation, and it is probable that it will be systematically taught in the English army.

Robert Jackson very strongly recommended that dancing should be taught and encouraged. There is sound sense in this; a spirited dance brings into play many muscles, and in a well-aired room is as good an exercise as can be taken. It would also be an amusement for the men.

Duties of the Officer in the Gymnasium.

The "Medical Regulations" order the inspecting medical officer and surgeon to visit, and advise on the kind and amount of gymnastic exercises. The "Queen's Regulations" (section 10, para. 8) order a strict medical examination of each man before the instruction is commenced. During the course further inspections are to be made—of the recruits once a fortnight, of trained soldiers monthly. The measurements of the recruit are also to be taken under the direction of the medical officer. The following points should be attended in regard to—

1. *Recruits.*—The recruit is inspected from time to time, to see if the system agrees with him.

(*a*) *Weight.*—The weight of the body should be ascertained at the beginning and end of the course, and during it, if the recruit in any way complains. With sufficient food recruits almost always gain in weight, therefore any loss of weight should at once call for strict inquiry. It may be the recruit is being overdone, and more rest may be necessary. But in order to avoid the greatest error, the weights must be carefully taken; if they are taken at all times of the day, without regard to food, exercise, etc., accuracy is impossible; there may be 2 lb or 3 lb variation. The physiological practice during experiments is to take the weight the first thing in the morning before breakfast, and after emptying the bladder. If it cannot be done at this time, scarcely any reliance can be placed on the result. Food alone may raise the weight 2 lb or 3 lb, and we cannot be sure that the same quantity of food is taken daily. The clothes, also, must be remembered; men should be weighed naked if possible, if not, in their trousers only, and always in the same dress.

(*b*) *Height.*—This is usually taken in the erect position. Dr. Aitken[1] recommends it to be taken when the body is stretched on a horizontal plane. A series of experiments on both plans would be very desirable.

(*c*) *Girth of Chest.*—The chest is measured to ascertain its absolute size, and its amount of expansion.

It is best measured when the man stands at attention, with the arms hanging; and the tape should pass round the nipple line. The double tape (the junction being placed on the spine) is a great improvement over the single tape, as it measures the sides separately, and with practice can be done as quickly.

The chest should be measured in the fullest expiration and fullest inspiration. If the chest is measured with the arms extended, or over the head, the scapulæ may throw out the tape from the side of the chest.

(*d*) *The Inspiratory Power*, as expressed by the spirometer, may also be employed.

(*e*) *Growth of Muscles.*—This is known by feeling the muscles when relaxed and in action, and by measurements. The measurement of the upper arm should be taken either when the arm is bent over the most

[1] On the Growth of the Recruit, p. 68.

prominent part of the biceps, or over the thickest part when the arm is extended.

(*f*) *General Condition of Health.*—Digestion, sleep, complexion, etc. The recruit should also be inspected during the time of exercise, to watch the effect on his heart, lungs, and muscles. In commencing training the great point is to educate, so to speak, the heart and lungs to perform suddenly, without injury, a great amount of work. To do this there is nothing better than practice in running and jumping. It is astonishing what effect this soon has. If possible, the increase in the number of respirations after running 200 or 300 yards should be noted on the first day, as this gives a standard by which to judge of the subsequent improvement. But as it would be impossible and a waste of time to do this with all the men, directly the run is ended the men should range in line, and the medical officer should pass rapidly down and pick out the men whose respiration is most hurried. In all the exercises the least difficulty of respiration should cause the exercise to be suspended for four or five minutes.[1] The heart should be watched; the characters indicating the necessity for rest or easier work are excessive rapidity (130–160), smallness, inequality, and irregularity.

Soreness of muscles after the exercise, or great weariness, should be inquired into. It would be well every now and then to try the inguinal and femoral rings during exertion and coughing.

One very important part in gymnastic training depends on the instructor. A good instructor varies the work constantly, and never urges a man to undue or repeated exertion. If the particular exercise cannot be done by any man it should be left for the time. Anything like urging or jeering by the rest of the men should be strictly discountenanced. The instructor should pass rapidly from exercise to exercise, so that a great variety of muscles may be brought into play for a short time each, and as the men work in classes, and all cannot be acting at once, there is necessarily a good deal of rest.

The grand rule for an instructor is, then, change of work and sufficient rest.

In the case of a recruit who has not been used to much physical exertion, the greatest care must be taken to give plenty of rest during the exercises. There may even seem to be an undue proportion of rest for the first fortnight, but it is really not lost time. The medical officer is only directed to visit the gymnasium once a fortnight, but during the first fortnight of the training of a batch of recruits he should visit it every day.

With proper care men are very seldom injured in gymnasia. Dr. Parkes was informed at Vincennes that, though they did not take men unless they were certified as fit by a medical officer, they occasionally got men with "delicate chests," though not absolutely diseased. These men always improved marvellously during the six months they remained at Vincennes. In fact, a regulated course of gymnastics is well known to be an important remedial measure in threatened phthisis. Hernia is never caused at Vincennes. Nor does it appear that any age is too great to be benefited by

[1] In the training of horses the points always attended to are—the very gradual increase of the exercise; gentle walking is persevered in for a long time, then slow gallops; then, as the horse gains wind and strength, quicker gallops; but the horse is never distressed, and a boy would be dismissed from a stable if it were known that the horse he was riding showed, by sighing, or in any other way, that the speed was too great for him.

gymnastics, though in old men the condition of the heart and vessels (as to rigidity) should be looked to.

Trained Soldiers.—There is less occasion for care with these men ; they should, however, be examined from time to time, and any great hurry of respiration noted. The man should be called out from the class, his heart examined, and some relaxation advised if necessary.

Drills and Marches.

In drill, and during marches, the movements of the soldiers are to a certain extent constrained. In the attitude of "attention" the heels are close together, the toes turned out at an angle of 60°, the arms hang close by the sides, the thumbs close to the forefingers, and on a line with the seam of the trousers. The position is not a secure one, as the basis of support is small, and in the manual and platoon exercise the constant shifting of the weight changes the centre of gravity every moment, so that constant muscular action is necessary to maintain the equilibrium. Men are therefore seldom kept long under attention, but are told to "stand at ease" and "stand easy," in which cases, and especially in the latter, the feet are farther apart and the muscles are less constrained.

In marching the attitude is still stiff—it is the position of attention, as it were, put into motion. The slight lateral movement which the easy walker makes when he brings the centre of gravity alternately over each foot, and the slight rotatory motion which the trunk makes on the hip-joint, is restrained as far as it can be, though it cannot be altogether avoided, as is proved by observing the light swaying motion of a line of even very steady men marching at quick time. Marching is certainly much more fatiguing than free walking ; and in the French army, and by many commanding officers in our own, the men are allowed to walk easily and disconnectedly, except when closed up for any special purpose. This may not look so striking to the eye of a novice, but to the real soldier, whose object is at the end of a long march to have his men so fresh that, if necessary, they could go at once into action, such easy marching is seen to be really more soldier-like than the constrained attitudes which lead so much sooner to the loss of the soldier's strength and activity.

In walking, the heel touches the ground first, and then rapidly the rest of the foot, and the great toe leaves the ground last. The soldier, in some countries, is taught to place the foot almost flat on the ground, but this is a mistake, as the body loses in part the advantage of the buffer-like mechanism of the heel. The toes are turned out at an angle of about 30° to 45°, and at each step the leg advances forward and a little outward ; the centre of gravity, which is between the navel and the pubis, about in a line with the promontory of the sacrum (Weber), is constantly shifting. It has been supposed that it would be of advantage to keep the foot quite straight, or to turn the toes a little in, and to let the feet advance almost in a line with each other. But the advantage of keeping the feet apart and the toes turned out, is that, first, the feet can advance in a straight line, which is obviously the action of the great *vasti* muscles in front of the thigh ; and, second, when the body is brought over the foot, the turned-out toes give a much broader base of support than when the foot is straight. The spring from the great toe may perhaps be a little greater when the foot is straight (although this is doubtful, and there seems no reason why the gastrocnemii and solei should contract better in this position), but there is a loss of

spring from the other toes. Besides this, it has been shown by Weber that when the leg is at its greatest length, *i.e.*, when it has just urged the body forward, and is lifted from the ground, it falls forward like a pendulum from its own weight, not from muscular action, and this advance is from within and behind to without and before, so that this action alone carries the leg outward.

The foot should be raised from the ground only so far as is necessary to clear obstacles. Formerly, in the Russian Imperial Guard, the men were taught to march with a peculiar high step, the knee being lifted almost to a level with the acetabulum. The effect was striking, but the waste of power was so great that long marches were impossible, and this kind of marching is now given up. The foot should never be advanced beyond the place where it is to be put down ; to do so is a waste of labor.

In the English army the order is as follows :—

Length and Number of Steps in Marching.

Kind of Step.	Length.	No. per Minute.	Ground Traversed per Minute.	Ground Traversed per hour without Halts.
	Inches.		Feet.	Miles.
Slow time.....	30	75	187½	2.1
Quick time.....	30	116	290	3.3
Stepping out.....	33	110	303½	3.4
Double.....	33	165	453¾	5.157
Stepping short.....	21			
Side step..... or when	12			
Forming four deep....	24			
Stepping back.....	30			

The "double" is never continued very long ; it is stopped at the option of the commanding officer. In the French army it is ordered not to be continued longer than twenty minutes. At the double (if without arms), the forearms are held horizontally, the elbows close to the side ; if the rifle is carried, one arm is so held. There is an advantage in this attitude, as the arms are brought into the position of least resistance ; more fixed points are given for the muscles of respiration, and the movement of the arms and shoulders facilitates the rapid shifting of the centre of gravity.

Quick time is always used in drills and marching. The ground got over per hour is generally reduced by halts to 2.8 miles.

Running drill has been introduced of late years ; it is not carried beyond 1,000 yards, and the men are gradually brought up to this amount. The pace is not to exceed 6 miles an hour. Weakly men (if considered unfit by the medical officers) are to be excused.[1]

In the French army the length of the step is rather different.

[1] Queen's Reg., section 10, para. 25*a*.

French Steps in English Measures (*Morache*, 1874).

	Length of Step in inches.	Steps per Minute.	Ground Traversed per Minute in Feet.	Ground Traversed per Hour in Miles.
Pas ordinaire (now seldom used).....	26	76	164	1.86
Pas de route.....	26	90	195	2.22
Pas accéléré.....	26	110	238	2.70
Pas de charge	29.5	120	295	3.35
Pas maximum (gymnastique).	32.5	165	449	5.10

The French step is therefore 4 inches shorter than the English; this is perhaps because the men are, as a rule, shorter. The Prussian and the Bavarian step is 31½ inches long, and 112 steps are taken per minute.

The exact length of the step, and the number per minute, are very important questions. The object of the soldier is to get the step as long, and the number per minute as great, as possible, without undue fatigue, so as to get over the greatest amount of ground.

The quickest movement of the leg forward in walking has been shown by Weber to correspond very closely with half a pendulum vibration of the leg, and to occupy, on an average, 0.357 seconds; this would give 168 steps per minute, supposing the one foot left the ground when the other touched it. This is much quicker than the army walking step (the double is a run), and no doubt much quicker than could long be borne, since, with a step of only 30 inches, it would give nearly 5 miles per hour; but it may be a question whether, with men in good condition, the pace might not be increased to 130 per minute. Practical trials, however, with soldiers carrying arms and accoutrements, can alone decide this point.

The length of the step of an average man has been fixed by the Brothers Weber at about 28 inches. In individual cases, it depends entirely on the length of the legs. Robert Jackson considered 30 inches as too long a step for the average soldier, and suggested 27 inches. It is of great importance not to lessen the length too much, and it would be very desirable to have some well-conducted experiments on this point. The steps must be shorter if weights are carried than without them; a little consideration shows how this is: When a man walks, he lifts his whole body and propels it forward, and in doing so the point of centre of gravity describes a circular motion, in the form of an arc about the foot. The less the body is raised, or, in other words, the shorter the versed sine of the arc, the less of course the labor. In long steps the arc, and of course the versed sine, or height to which the body is raised, are greater; in short steps, less.[1] It is probable, with the weight the soldier carries (60 lb), the step of 30 inches is quite long enough, perhaps even too long; and it would be desirable to know if, after a march of six or eight miles, the steps do not get shorter.

In the French army the march is commenced at the *pas de route* (90 steps per minute); then accelerated to 110 steps; during the last half-hour

[1] The Brothers Weber, however, have shown that the angle at which the body is bent and, consequently, the coefficient of resistance are not affected by the length of step, provided the velocity remains the same.

100 steps are returned to. But the soldiers themselves often set the step; the grenadiers and the voltigeurs alternately leading. Four kilometres (= 2½ miles) per hour is considered a good general average (Morache).

The soldier, in this country, when he marches in time of peace in heavy order, carries his pack, kit, haversack, water-bottle, great-coat, rifle, and ammunition (probably twenty rounds). In India he does not carry his pack or great-coat.

There is a very general impression that the best marchers are men of middle size, and that very tall men do not march so well.

Length of the March.—In "marching out" in time of peace, which is done once or twice a week in the winter, the distance is 8 or 10 miles.[1] In marching on the route or in war, the distance is from 10 or 12 miles to occasionally 18 or 20, but that is a long march. A forced march is any distance—25 to 30, and occasionally even 40 miles being got over in twenty-four hours. In the French army the length of march is from 20 to 25 kilometres (12½ to 15 miles). In the Prussian army the usual march is 14 miles (English); if the march is continuous, there is a halt every fourth day.

Conditions rendering Marches Slower.—The larger the body of men the slower the march; 14 miles will be done in six or seven hours by two or three regiments, but not under eight or nine hours by 8,000 or 10,000 men. A large army will not go over 14 miles under ten hours usually. A single regiment can do 20 miles in eight hours, but a large army will take twelve or fourteen, including halts. Head winds greatly delay marches; a very strong wind acting on a body of men will cause a difference of 20 to 25 per cent., or only 4 miles will be got over instead of 5.

Snow and rain, without head wind, delay about 10 to 15 per cent., or 4½ miles are done instead of 5.

Of course, bad or slippery roads, deep sands, heavy snows, jungle and brushwood, are often acting against the soldier, and in hilly and jungly countries only 5 or 6 miles may be got over in a day.

Conditions adding to the Fatigue of Marching.—Heat—dust—thirst—constant halts from obstructions—want of food—bad weather, especially head winds with rain. In order to avoid heat and dust, it is desirable, when it can be done, to separate the cavalry and artillery from the infantry; to let the latter march in open order, and with as large a front as possible.

Instances of Marches during War.—It is most important for a soldier to know what has been done and what can be done with a large body of foot soldiers, and it is scarcely less interesting to the physiologist. In comparing the marches of infantry, it must always be remembered how great an effect increasing the number of men has in lessening the rapidity and length of a march, and in increasing the fatigue. No large army has ever made the marches small bodies of troops have done.

At times the fatigue undergone by trained men has been something almost incredible. Wolfe mentions in one of his letters that in 1743, just before the battle of Dettingen, his regiment marched from Frankfort "two days and two nights with only nine or ten hours' halt." This would be a march of thirty-eight hours out of forty-eight. He gives the distance at about 40 miles, but it was probably more. The 43d, 52d, and 95th Regiments of Foot, forming the Light Division under Crawfurd, made a forced march in July, 1809, in Spain, in order to reinforce Sir Arthur Wellesley at the battle of Talavera. About fifty weakly men were left

[1] Queen's Regulations (1881, section 16, para. 30). See also Field Exercise (1877).

behind, and the brigade then marched 62 miles in twenty-six hours, carrying arms, ammunition, and pack—in all, a weight of between 50 lb and 60 lb.[1] There were only seventeen stragglers. The men had been well trained in marching during the previous month.

One of these regiments—the 52d—made in India, in 1857, a march nearly as extraordinary. In the height of the mutiny, intelligence reached them of the locality of the rebels from Sealkote. The 52d, and some artillery, started at night on the 10th of July, 1857, from Umritzur, and reached Goodasepore, 42 miles off, in twenty hours, some part of the march being in the sun. On the following morning they marched 10 miles, and engaged the mutineers. They were for the first time clad in the comfortable gray or dust-colored native khakee cloth.

A march of a small party of French was narrated by an officer of the party, who was afterward wounded at Sedan, to Dr. Frank. A company of a regiment of Chasseurs of MacMahon's army, after being on grand guard, without shelter or fire, during the rainy night of the 5th–6th August, 1870, started at three in the morning to rejoin its regiment in retreat on Niederbronn, after the battle of Weissenburg. It arrived at this village at 3.30 in the afternoon, and started again for Phalsbourg at six o'clock. The road was across the hills, and along forest tracts, which were very difficult for troops. It arrived at Phalsbourg at 8.30 o'clock in the evening of the next day. The men had, therefore, marched part of the night of the 5th–6th August, the day of the 6th, the night of the 6th–7th, and day of the 7th till 8.30 P.M. The halts were eight minutes every hour, from 3.30 to 6, one hour in the night of the 6th–7th, and 2½ hours on the 7th. Altogether, including the halts, the march lasted 41½ hours, and the men must have been actually on their feet about thirty hours, in addition to the guard duty on the night before the march.

An officer of a Saxon Fusilier regiment gave the following statement of a forced march in one of the actions at Metz, in 1870. The regiment was alarmed at midnight and marched at one A.M.; and continued marching with halts until 7 P.M.; they bivouacked for the night, marched at 7 the next morning, came into action at 1.30, and in the evening found themselves 15 kilometres beyond the field of battle. The total distance was 53½ miles in about forty-two hours, with probably fifteen hours' halt.

Roth mentions that the 18th division of the Saxon army, in the various manœuvres about Orleans, marched, on the 16th and 17th December, 1870, 54 English miles.

Von der Tann's Bavarian army, in retreat on Orleans, marched 42 miles in twenty-six hours.

These were all forced marches for the purpose of coming into action or retiring after discomfiture. Apart from the Peninsular Light Division march, they show that in two days and one night a small body of men may cover 54 English miles, and that is probably near the limit of endurance. The Light Division march is so excessive (62 miles in twenty-six

[1] Napier's War in the Peninsula, 3d edit., vol. ii., p. 400; Moorsom's Record of the 52d Regiment, p. 115. Both authors state that the men carried between 50 lb and 60 lb on this extraordinary march, but there seems a little doubt of this. During the Peninsular war the men carried bags, weighing about 2 lb, and not framed packs, and their kits were very scanty. Lord Clyde, in talking of this march to Surgeon-General Longmore, told him the men only carried a shirt and a spare pair of either boots or soles. He saw the men march in. In all probability also they would not carry their full ammunition.

hours, or 2.38 miles every hour, without reckoning halts), that it may be doubted if the distance was properly reckoned.[1]

When a large army moves it has never accomplished such distances.

In 1806 the French army marched on one occasion 49 kilometres, or 30½ miles. On June 15, 1815, Napoleon made a forced march to surprise the Prussians and English, but only accomplished 30 kilometres or 18⅔ miles.

In Sherman's celebrated march across the Southern States the daily distance was about 14 miles. When the Prussians advanced on Vienna, after the battle of Königgrätz, in 1866, they accomplished almost the same, and had also outpost duty every other night.

The Russians marched in the expedition to Khiva, in 1873, 468.7 miles (English) in 89 days, but as actual marching was done only on 44 days, the average daily march was (468.7 ÷ 44) 10.65 miles; the longest march was 26½ miles.[2]

MacMahon's army, in its march to relieve Bazaine at Metz, could only accomplish about 10 miles daily, while the Crown Prince of Prussia in pursuit was far more rapid.

After Sedan, the Prussian and Saxon troops pushed on to Paris by forced marches, and accomplished on an average 35 kilometres, or 21⅔ miles, daily, and they marched on some days 42 to 45 kilometres (26 to 28 miles); they started at five or six, and were on their ground from four to eight o'clock, the average pace being 5 kilometres (3.1 miles) per hour.

In the Indian mutiny several regiments marched 30 miles a day for several days.

When marches are continued day after day, an average of about 20 miles may be expected from men for two or three weeks, after which, probably, the amount would lessen.

It is difficult to estimate the labor of such marches, as besides the actual march there is often work in fetching water, cooking, pitching tents, sentry, outpost, and picket duty, etc. As 20 miles a day with 60 lb weight is equivalent to lifting 495 tons one foot, and there is always additional work to be done, it is clear that the labor is excessive, and must be prepared for, and that during the time the men must be well fed.

[1] Sir William Cope, who was one of the officers of the 95th, says (in his History of the Rifle Brigade, formerly the 95th) that the distance was only 40 miles.

[2] In 1709, on the 3d September, in order to secure the passage of the Haine, the Prince of Hesse-Cassel made a march of 49 English miles in 56 successive hours, with 4,000 foot and 60 squadrons (Coxe's Life of Marlborough, v. 10–21).

Alison (History of Marlborough, vol. ii., p. 27) says that "this rapidity of advance for such a distance had never been previously surpassed, though it has been outdone in later times." He refers in a footnote to Mackenzie's march to join Wellington at Talavera, which he gives as 62 English miles in 26 hours; also the Russian foot guards advancing to Paris in 1814, after the combat at Fère-Champenoise, marched 48 miles in 26 hours.

In the Times of 1873, a writer gives the following statement; he quotes from a despatch published in the London Gazette of 1859:—"During the day the troops from Khulkhulla marched 35 miles, and those from the camp 48 miles, and much of this under a more than usually hot sun." He also says that at the end of 1858, General Whitlock marched 86 miles in 37 hours to relieve Kirwee.

In April, 1859, Colonel De Salis (London Gazette, 1859) reported a march of not less than 40 miles. Captain Rennie's force also marched 40 miles in 24 hours. In the same number of the Times Captain Carleton states that Daly's Guide Corps marched from near Peshawur to Delhi, 580 miles, in 22 days. Sir Hope Grant says 750 miles in 28 days. He also says that the 1st Bengal Fusiliers (European) marched 68 miles in 38 hours.

In marching long distances, the extent of the marches, the halting grounds, etc., are fixed by the Quartermaster-General's department.

Occasionally the march has been divided, one part being done in the early morning, and the remainder late in the afternoon. It is, however, better to make the march continuous, and, if necessary, to lengthen the mid-day halt.

Order of March.—Whenever possible, it seems desirable to march in open order. Inspector-General J. R. Taylor has given evidence to show that a close order of ranks is a cause of unhealthiness in marching, similar to that of overcrowding in barracks; and the Medical Board of Bengal, in accordance with this opinion, recommended that military movements in close order should be as little practised as possible. There should also be as much interval as can be allowed between bodies of troops.

Effects of Marches.—Under ordinary conditions, both in cold and hot countries, men are healthy on the march.

But marches are sometimes hurtful—

1st. When a single long and heavy march is undertaken when the men are overloaded, without food, and perhaps without water. The men fall out, and the road becomes strewed with stragglers. Sometimes the loss of life has been great.

The prevention of these catastrophes is easy. Place the soldier as much as possible in the position of the professional pedestrian; let his clothes and accoutrements be adapted to his work; supply him with water and proper food, and exclude spirits; if unusual or rapid exertion is demanded, the weights must be still more lightened.

When a soldier falls out on the march he will be found partially fainting, with cold moist extremities, a profuse sweat everywhere; the pulse is very quick and weak—often irregular; the respiration often sighing. The weights should be removed, clothes loosened, the man laid on the ground, cold water dashed on the face, and water given to drink in small quantities. If the syncope is very alarming, brandy must be used as the only way of keeping the heart acting, but a large quantity is dangerous. If it can be obtained, weak hot brandy and water is the best under these circumstances. When he has recovered, the man must not march—he should be carried in a wagon, and in a few minutes have something to eat, but not much at a time. Concentrated beef-tea mixed with wine is a powerful restorative, just as it is to wounded men on the field.

2d. When the marches which singly are not too long, are prolonged over many days or weeks without due rest.

With proper halts men will march easily from 500 to 1,000 miles, or even farther, or from 12 to 16 miles per diem, and be all the better for it; but after the second or third week, there must be one halt in the week besides Sunday. If not, the work begins to tell on the men; they get out of condition, the muscles get soft, appetite declines, and there may be even a little anæmia. The same effects are produced with a much less quantity of work, if the food is insufficient. Bad food and insufficient rest are then the great causes of this condition of body.

In such a state of body malarious fevers are intensified, and in India attacks of cholera are more frequent. It has been supposed that the body is overladen with the products of metamorphosis, which cannot be oxidized fast enough to be removed.

Directly the least trace of loss of condition begins to be perceived in the more weakly men (who are the tests in this case), the surgeon should advise the additional halt, if military exigencies permit. On the halt day

the men should wash themselves and their clothes, and parade, but should not drill.

3d. When special circumstances produce diseases.

Exposure to wet and cold in temperate climates is the great foe of the soldier. As long as he is marching, no great harm results ; and if at night he can have dry and warm lodgings, he can bear, when seasoned, great exposure. But if he is exposed at night as well as day, and in war he often is so, and never gets dry, the hardiest men will suffer. Affections arising from cold, such as catarrhs, rheumatism, pulmonary inflammation, and dysentery are caused.

These are incidental to the soldier's life, and can never be altogether avoided. But one great boon can be given to him; a waterproof sheet, which can cover him both day and night, has been found the greatest comfort by those who have tried it.

The soldier may have to march through malarious regions. The march should then be at mid-day in cold regions, in the afternoon in hot. The early morning marches of the tropics should be given up for the time; the deadliest time for the malaria is at and soon after sunrise. If a specially deadly narrow district has to be got through, such as a Terai, at the foot of hills, a single long march should be ordered ; a thoroughly good meal, with wine, should be taken before starting, and if it can be done, a dose of quinine. If the troops must halt a night in such a district, every man should take five grains of quinine. Tents should be pitched in accordance with the rules laid down in the chapter on CAMPS, and the men should not leave them till the sun is well up in the heavens.

Yellow fever or cholera may break out. The rules in both cases are the same. At once leave the line of march ; take a short march at right angles to the wind ; separate the sick men, and place the hospital tent to leeward ; let every evacuation and vomited matter be at once buried and covered with earth, or burnt, if possible, and employ natives (if in India) to do this constantly, with a sergeant to superintend. Let every duty-man who goes twice to the rear in six hours report himself, and, if the disease be cholera, distribute pills of acetate of lead and opium to all the non-commissioned officers. Directly a man who becomes choleraic has used a latrine, either abandon it, or cover it with earth and lime if it can be procured. If there is carbolic acid or chloride of zinc, or lime or sulphate of iron or zinc at hand, add some to every stool or vomit.

In two days, whether the cholera has stopped or not, move two miles ; take care in the old camp to cover or burn everything, so that it may not prove a focus of disease for others. The drinking water should be constantly looked to. A regiment should never follow one which carries cholera ; it should avoid towns where cholera prevails; if it itself carries cholera, the men should not be allowed to enter towns. Many instances are known in India where cholera was in this way introduced into a town.

The men may suffer from insolation. This will generally be under three conditions. Excessive solar heat in men unaccustomed to it and wrongly dressed, as in the case of the 98th in the first China war, when the men having first landed from a six months' voyage, and being buttoned up and wearing stocks, fell in numbers during the first short march. A friend who followed with the rearguard informed Dr. Parkes that the men fell on their faces as if struck by lightning ; on running up and turning them over, he found many of them already dead. They had, no doubt, struggled on to the last moment. This seems to be intense asphyxia, with sudden failure of the heart-action, and is the "cardiac variety" of Morehead.

A dress to allow perfectly free respiration (freedom from pressure on chest and neck), and protection of the head and spine from the sun, will generally prevent this form. The head-dress may be wetted from time to time; a piece of wet paper in the crown of the cap is useful. When the attack has occurred, cold affusion, artificial respiration, ammonia, and hot brandy and water to act on the heart, seem the best measures. Bleeding is hurtful; perhaps fatal. Cold affusion must not be pushed to excess.

In a second form the men are exposed to continued heat,[1] both in the sun and out of it, day and night, and the atmosphere is still, and perhaps moist, so that evaporation is lessened, or the air is vitiated. If much exertion is taken, the freest perspiration is then necessary to keep down the heat of the body; if any thing checks this, and the skin gets dry, a certain amount of pyrexia occurs; the pulse rises; the head aches; the eyes get congested; there is a frequent desire to micturate (Longmore), and gradual or sudden coma, with perhaps convulsions and stertor, comes on, even sometimes when a man is lying quiet in his tent. The causes of the interruption to perspiration are not known; it may be that the skin is acted upon in some way by the heat, and from being over-stimulated, at last becomes inactive.

In this form cold affusion, ice to the head, and ice taken by the mouth, are the best remedies; perhaps even ice water by the rectum might be tried. Stimulants are hurtful. The exact pathology of this form of insolation is uncertain. It is the cerebro-spinal variety of Morehead.

In a third form a man is exposed to a hot land-wind; perhaps, as many have been, from lying drunk without cover. When brought in, there is generally complete coma with dilated pupils, and a very darkly flushed face. After death the most striking point is the enormous congestion of the lungs, which is also marked, though less so, in the other varieties. Dr. Parkes stated that he had never seen anything like the enormous congestion he had observed in two or three cases of this kind.

As prevention of all forms, the following points should be attended to:—Suitable clothing; plenty of cold drinking water (Crawford); ventilation; production in buildings of currents of air; bathing; avoidance of spirits; lessening of exertion demanded from the men.

Duty of Medical Officers during Marches.

General Duties on Marches in India or the Colonies.—Before commencing the march, order all men with sore feet to report themselves. See that all the men have their proper kits, neither more nor less. Every man should be provided with a water-bottle to hold not less than a pint. Inspect halting-grounds, if possible; see that they are perfectly clean, and that everything is ready for the men. In India, on some of the trunk roads there are regular halting-grounds set apart. The conservancy of these should be very carefully looked to, else they become nothing but foci for disseminating disease. If there are no such places, halting-grounds are selected. It should be a rule never to occupy an encamping ground previously used by another corps if it can be avoided; this applies to all cases. Select a position to windward of such an old camp, and keep as far as possible from it. The encampments of the transport department, elephants, camels, bullock

[1] The heat of sandy plains is the worst, probably, from the great absorption of heat and the continued radiation. The heat of the sun, *per se*, is not so bad; on board ship sun-stroke is uncommon.

carts, etc., must be looked to,—they often are very dirty; keep them to leeward of the camp, not too near, and see especially that there is no chance of their contaminating streams supplying drinking water. If the encampment is on the banks of the stream, the proper place for the native camp and bazaar will always be lower down the stream. The junior medical officer, if he can be spared, should be sent forward for this purpose with a combatant officer. Advise on length of marches, halts, etc., and draw up a set of plain rules to be promulgated by the commanding officer, directing the men how to manage on the march if exposed to great heat or cold, or to long-continued exertion, how to purify water, clean their clothes, etc. If the march is to last some time, and if halts are made for two or three days at a time, write a set of instructions for ventilating and cleaning tents, regulation of latrines, etc.

Special Duties for the March itself.—Inspect the breakfast or morning refreshment; see that the men get their coffee, etc. On no account allow a morning dram, either in malarious regions or elsewhere. Inspect the water-casks, and see them properly placed, so that the men may be supplied; inspect some of the men, to see that the water-bottles are full. March in rear of the regiment so as to pick up all the men that fall out, and order men who cannot march to be carried in wagons, dhoolies, etc., or to be relieved of their packs, etc. If there are two medical officers, the senior should be in rear; if a regiment marches in divisions, the senior is ordered to be with the last. When men are ordered either to be carried or to have their packs carried, tickets should be given specifying the length of time they are to be carried. These tickets should be prepared before the march, so that nothing has to be done but to fill in the man's name, and the length he is to be carried.

Special orders should be given that, at the halt, or at the end of the day's march, the heated men should not uncover themselves. They should take off their pack and belts, but keep on the clothes, and, if very hot, should put on their great-coats. The reason of this (viz., the great danger of chill *after* exertion) should be explained to them. In an hour after the end of the march the men should change their underclothing, and hang the wet things up to dry; when dry they should be shaken well, and put by for the following day. Some officers, however, prefer that their men should at once change their clothes and put on dry things. This is certainly more comfortable. But, at any rate, exposure must be prevented.

At the end of the march inspect the footsore men. Footsoreness is generally a great trouble, and frequently arises from faulty boots, undue pressure, chafing, riding of the toes from narrow soles, etc. Rubbing the feet with tallow, or oil or fat of any kind, before marching, is a common remedy. In the late war the Germans found tannin very useful,—they used an ointment of one part of tannin to twenty parts of zinc ointment. A good plan is to dip the feet in very hot water, before starting, for a minute or two; wipe them quite dry, then rub them with soap (soft soap is the best), till there is a lather; then put on the stocking. At the end of the day, if the feet are sore, they should be wiped with a wet cloth, and rubbed with tallow and spirits mixed in the palm of the hand (Galton). Pedestrians frequently use hot salt and water at night, and add a little alum. Sometimes the soreness is owing simply to a bad stocking; this is easily remedied. Stockings should be frequently washed; then greased. Some of the German troops use no stockings, but rags folded smooth over the feet. The French use no stockings. Very often soreness is owing to neglected corns, bunions, or in-growing nails, and the surgeon must not despise the little

surgery necessary to remedy these things; nothing, in fact, can be called little if it conduces to efficiency. As shoes are often to blame for sore feet, it becomes a question whether it might not be well to accustom the soldier to do without shoes.

Frequently men fall out on the march to empty the bowels; the frequency with which men thus lagging behind the column were cut off by Arabs, led the French in Algeria to introduce the slit in the Zouave trousers, which require no unbuckling at the waist, and take no time for adjustment.

At a long halt, if there is plenty of water, the shoes and stockings should be taken off, and the feet well washed; even wiping with a wet towel is very refreshing. The feet should always be washed at the end of the march.

Occasionally men are much annoyed with chafing between the nates, or inside of the thighs. Sometimes this is simply owing to the clothes, but sometimes to the actual chafing of the parts. Powders are said to be the best—flour, oxide of zinc, and above all, it is said, fuller's earth.

If blisters form on the feet, the men should be directed not to open them during the march, but at the end of the time to draw a needle and thread through; the fluid gradually oozes out.

All footsore men should be ordered to report themselves at once.

Sprains are best treated with rags dipped in cold water, or cold spirit and water with nitre, and bound tolerably tight round the part. Rest is often impossible. Hot fomentations, when procurable, will relieve pain.[1]

Marches, especially if hurried, sometimes lead men to neglect their bowels, and some trouble occurs in this way. As a rule, it is desirable to avoid purgative medicines on the line of march, but this cannot always be done; they should, however, be as mild as possible.

Robert Jackson strongly advised the use of vinegar and water as a refreshing beverage, having probably taken this idea from the Romans, who made vinegar one of the necessaries of the soldier. It was probably used by them as an anti-scorbutic; whether it is very refreshing to a fatigued man seems uncertain.

There is only one occasion when spirits should be issued on a march: this is on forced marches, near the end of the time, when the exhaustion is great. A little spirit, in a large quantity of hot water, may then be useful, but it should only be used on great emergency. Warm beer or tea is also good; the warmth seems an important point. Ranald Martin and Parkes tell us that in the most severe work in Burmah, in the hot months of April and May, and in the hot hours of the day, warm tea was the most refreshing beverage. Travellers in India, and in bush travelling in Australia, have said there was nothing so reviving as warm tea. Chevers mentions that the juice of the country onion is useful in lessening thirst during marches in India, and that, in cases of sun-stroke, the natives use the juice of the unripe mangoe mixed with salt.

Music on the march is very invigorating to tired men. Singing should also be encouraged as much as possible.

Marching in India.—Marches take place in the cool season (November to February), and not in the hot or rainy seasons, except on emergency; yet marches have been made in hot weather without harm, when care is taken. They are conducted much in the same way as in cold countries, except that

[1] The following is a very good lotion for sprains: sal-ammoniac, 20 grains, vinegar and spirit, an ounce of each.

the very early morning is usually chosen. The men are roused at half-past two or three, and parade half an hour later; the tents are struck, and carried on by the tent-bearers; coffee is served out, and the men march off by half-past three or four, and end at half-past seven. Everything is ready at the halting-ground, tents are pitched, and breakfast is prepared.

These very early marches are strongly advocated by many, and are opposed almost as strongly by some. In the West Indies, marching in the sun has always been more common than in the East. Much must depend on the locality, and the prevalence and time of hot land winds. Both in India and Algeria marches have been made at night; the evidence of the effects of this is discordant. The French have generally found it did not answer; men bear fatigue less well at night; and it is stated that the admissions into hospital have always increased among the French after night marching. Annesley's authority is also against night marching in India. On the other hand, it is stated by some that in India the march through the cool moonlight night has been found both pleasant and healthy.

Afternoon marches (commencing about two hours before sunset) have been tried in India, and often apparently with very good results.

Marching in Canada.—In 1814, during the war with America; in 1837, during the rebellion; and, in 1861–62, during the Trent excitement, winter marches were made by the troops, in all cases without loss. The following winter clothing was issued at home:—A sealskin cap with ear lappets; a woollen comforter; two woollen jerseys; two pairs of woollen drawers; a chamois leathern vest with arms; two pairs long woollen stockings to draw over the boots; sealskin mits; and a pair of jackboots. In Canada a pair of blankets and mocassins were added,[1] and, at the long halts, weak hot rum and water was served out. A quarter of a pound of meat was added to the ration. A hot meal was given before starting, another at mid-day, and another at night. The troops were extremely healthy. During exposure to cold, spirits must be avoided; hot coffee, tea, ginger tea, or hot weak wine and water, are the best; it is a good plan to rub the hands, feet, face, and neck with oil; it appears to lessen the radiation of heat and the cooling effect of winds.

[1] See Inspector-General Muir's Report, Army Medical Reports, vol. iv., p. 378.

CHAPTER III.

THE EFFECTS OF MILITARY SERVICE.

The influence of the various conditions of military life is shown by the records of sickness and mortality, and this must be noted in the various stations.

The recruit having entered the ranks, begins his service at home, and he is kept at his depôt for some time. He does not go on foreign service until he has completed his twentieth year. We should suppose his life would be a healthy one. It is a muscular, and, to a certain extent, an open-air life, yet without great exposure or excessive labor; the food is good (though there might be some improvement), the lodging is now becoming excellent, and the principles of sanitation of dwellings are carefully practised. Although the mode of clothing might be improved as regards pressure, still the material is very good. There is a freedom from the pecuniary anxiety which often presses so hardly on the civil artisan, and in illness the soldier receives more immediate and greater care than is usual in the class from which he comes.

There are some counterbalancing considerations. In a barrack, there is great compression of the population, and beyond a doubt the soldier has greatly suffered, and even now suffers, from the foul air of barrack rooms. But this danger is greatly lessening, owing to the exertions of the Barrack Improvement Commissioners, and, as is proved by the experience of some convict jails, can be altogether avoided.

Among the duties of the soldier is some amount of night-work; it is certain that this is a serious strain, and the Sanitary Commissioners, therefore, inserted in the "Medical Regulations" an order that the number of nights in bed should be carefully reported by medical officers. Major-General Sir Frederick Roberts, G.C.B., has lately called marked attention to the injurious effects of night duty and "sentry-go."[1] Commanding officers should be informed how seriously the guard and sentry duties, conducted as they are in full dress, tell on the men if they are too frequent; one guard-day in five is quite often enough, and four nights in bed should be secured to the men. Exposure during guard and transition of temperature on passing from the hot air of the guard-room to the outside air are also causes of disease. The weights and accoutrements are heavy, but the valise equipment introduced by General Eyre's Committee has removed the evil of the old knapsack.

The habits of the soldier are unfavorable to health; in the infantry, especially, he has much spare time on his hands, and *ennui* presses on him. *Ennui* is, in fact, the great bane of armies; though it is less in our own than in many others. It is said to weigh heavily on the German, the Russian, and even on the French army. Hence, indeed, part of the restlessness

[1] Nineteenth Century, November, 1882.

and one of the dangers of large standing armies. The Romans appear to have avoided this danger by making their distant legions stationary, and permitting marriage and settlement—in fact, by converting them into military colonies. We avoid it in part by our frequent changes of place, and our colonial and Indian service; but not the less, both at home and abroad, do idleness and *ennui*, the parents of all evils, lead the soldier into habits which sap his health. Not merely excessive smoking, drinking, and debauchery, but in the tropics mere laziness and inertia, have to be combated. Much is now being done by establishing reading-rooms, trades, industrial exhibitions, etc., and by the encouragement of athletic sports to occupy spare time, and already good results have been produced.

The establishment of trades, especially, which will not only interest the soldier, but benefit him pecuniarily, is a matter of great importance. It has long been asked why an army should not do all its own work; give the men the hope and opportunity of benefiting themselves, and *ennui* would no longer exist. In India, Lord Strathnairn did most essential service by the establishment of trades; and the system, after long discussion and many reports, is now being tried in England.

One of the proofs of ability for command and administration is the power of occupying men, not in routine, but in interesting and pleasant work, to such an extent that rest and idleness may be welcomed as a change, not felt as a burden. Constant mental and much bodily movement is a necessity for all men; it is for the officers to give to their men an impulse in the proper direction.

The last point which, probably, makes the soldier's life less healthy than it would otherwise be, is the depressing moral effect of severe and harassing discipline. In our own army in former years, it is impossible to doubt that discipline was not merely unnecessarily severe, but was absolutely savage. An enlightened public opinion has gradually altered this, and with good commanding officers, the discipline of some regiments is probably nearly perfect; that is to say, regular, systematic, and unfailing; but from its very justice and regularity, and from its judiciousness, not felt as irksome and oppressive by the men.

The general result of the life at home on soldiers must now be considered.

It is by no means easy to say whether soldiers enjoy as vigorous health as the classes from which they are drawn; the comparison of the number of sick, or of days' work lost by illness by artisans cannot be made, as soldiers often go into hospital for slight ailments which will not cause an artisan to give up work. The comparative amount of mortality seems the only available test, though it cannot be considered a very good one.

Following the order laid down in the chapter on STATISTICS, we have to consider—

SECTION I.

THE LOSS OF STRENGTH BY DEATH AND INVALIDING, PER 1,000, PER ANNUM.

A. BY DEATH.

It is to be understood that the mortality is here reckoned on the strength, that is, on the total number of healthy and sick persons actually serving during the time. The mortality on the sick alone is another matter.

From the Parliamentary Statistical Returns of the Army (1840 and 1853, which include the years 1826–1846), we find that the mortality among the cavalry of the line was at that time about one-third more than among the civil male population at the same age (nearly as 15 to 10[1] per 1,000); among the Foot Guards it was more than double (very. nearly 20½ per 1,000 as against 10); among the infantry of the line it was three-fourths more (or 18 per 1,000 as against 10).

The State was thus losing a large body of men annually in excess of what would have been the case had there been no army, and was therefore not only suffering a loss, but incurring a heavy responsibility.

In the splendid men of the Household Brigade, diseases of the lungs (including phthisis) accounted for no less that 67.7 per cent. of the deaths, in the cavalry of the line for nearly 50 per cent., and in the infantry of the line for 57 per cent.; while among the civil population of the soldiers' age, the proportion in all England and Wales was only 44.5 per cent. of the total deaths. The next chief causes of deaths were fevers, which accounted in the different arms of the service for from 7 to 14 per cent. of the total deaths. The remainder of the causes of deaths were made up of smaller items.

These remarkable results were not peculiar to the English Army. Most armies did, some still do, lose more than the male civil population at the same age. The following are the most reliable statistics:—[2]

	Army Loss per 1,000.
France (1823)	28.3
France (Paixhans, 1846)	19.9
France, mean of 7 years (1862–68)	10.0
France (1869)	9.55
France (1872)	9.49
French in Algeria (1846)	64
French in Algeria (1862–66)	14.98
Prussian[3] (1846–1863, including officers)	9.49
Prussian (1869)	6.10
Prussian army (including the Saxon and Würtemberg corps (1876).	4.96
Prussian[4] (1867)	6.54
Russian[5] (series of years)	39
Russian (1857–1866)	18.7
Austrian	28
Austrian (1869)	11.58
Piedmontese (1859)	16
Italian (1870)	8.40
United States (before the war)	18.8
Portuguese (1851–53)	16.5
Danish	9.5

[1] In reality the deaths from the civil male population of the soldiers' ages (20 to 40) were below ten, and in the healthy districts much below; the case against the soldier is, therefore, even worse than it reads in the text.

[2] Meyne (Eléments de Stat. Méd. Militaire, 1859) gives some of these figures; others are taken from the reports of the different armies.

[3] Dr. Engel, in Zt. des Königl. Preussich. Stat. Bureaus, Aug.–Sept., 1865, p. 214.

[4] Stat. Sanitäts-bericht über die Kon. Pr. Armee, for 1867, Berlin, 1870. Without deaths of invalids the mortality was only 6.196. The men were all under thirty years of age, which must be taken into account.

[5] The Russian mortality has lately been greatly reduced.

The old Hanoverian army was very healthy, losing only 5.3 per 1,000 as against 9.5 among the civil population of the same ages.

In these foreign armies the same rule holds good; fevers (chiefly typhoid in all probability) and phthisis were the great causes of mortality. In Prussia phthisis formerly caused 27 per cent. of the total mortality, but in that army phthisical men are sent home, and after a certain time are struck off the rolls, so that the army deaths are thus fewer than they would be if the men died at their regiments. In Austria phthisis caused 25 deaths out of every 100; in France, 22.9;[1] while in 1859, the proportion among the civil population was 17.76; in Hanover, 39.4; and in Belgium, 30; though in the latter country the proportion among the civil population was only 18.97 deaths from phthisis per 100 of all deaths. In Portugal the mortality from phthisis constituted 22 per cent. of the deaths,[2] while in the civil population the deaths are 12 per cent. of the total deaths. In the Prussian army in 1876 only 16 per cent. were from phthisis. In these armies, also, fevers caused a greater number of the deaths than in the English army, even in the period referred to. In Prussia, 36 (reduced in 1876 to 20); in France, 26;[3] in Belgium, 16.6; and in Hanover, 23.68 per cent. of all deaths were from fever (typhoid?). In Portugal only 3.9 deaths are from typhoid out of every 100 deaths; this is owing to its rarity in the country districts; it is common in Lisbon.

Nothing can prove more clearly that in all these armies the same causes were in action. And from what has been said in previous chapters, it may be concluded that the reason of the predominance of these two classes, lung diseases and typhoid fever, must be sought in the impure barrack air, and in the defective removal of excreta.

The Crimean war commenced in 1854, and ended in 1856. A large part of the army was destroyed, and a fresh force of younger men took its place. Soon afterward, the great sanitary reforms of Lord Herbert commenced. In 1859 yearly statistical returns began to be published.

The mortality of all arms has undergone an extraordinary decrease from that of the former period.

Mortality per 1,000, *per Annum, in United Kingdom.*

	From all Causes.	From Disease alone (*i.e.*, excluding violent deaths).
Mean of ten years, 1861–70	9.45	8.534
Mean of ten years, 1870–79	8.18	
1880	6.83	5.876

The diminution over the years previously noted (1826–46) is extraordinary. Three causes only can be assigned for it—the youth of the army, and a better selection of men; or a partial removal of the causes of diseases; or earlier invaliding, and the action of the Limited Enlistment Act, so as to throw the fatal cases on the civil population.

[1] This was in 1860; calculated from Laveran's returns from eleven of the great garrisons.

[2] Marques, reviewed in an excellent article in the British and Foreign Medico-Chir. Review for April, 1863.

[3] Laveran, in 1860, made the number 25.9 in the deaths from eleven garrisons. In 1863 the mortality from typhoid in the French army was 1.87 per 1,000 of effectives in France, 1.63 in Algeria, and 3.55 in Italy. In 1866 the mortality was 1.45 in France, 1.39 in Algeria, and 2.26 in Italy.

The question of age has been examined and disposed of by Dr. Balfour,[1] who has shown that the youth of the army does not account for the lessening. Selection has always been made with equal care, and invaliding, though it certainly has been greater of late years, does not appear to have been in excess sufficient to account for the lessening. There can be no doubt, then, that the great result of halving the yearly loss of the army by disease has been the work of Lord Herbert and the Royal Sanitary Commission.

It will be observed that the amount of the mortality in the French army was also singularly lessened from 1846 to 1862 and 1863, and this is, no doubt, owing to the great sanitary precautions now taken in that army.

Of the different arms of the service, the cavalry and artillery are rather healthier than the infantry; the engineers than either; the officers always show less mortality than the non-commissioned officers and privates, and the non-commissioned officers less than the privates. In different regiments there is often a singular difference in the mortality in a given year, but this is usually easily accounted for, and in a term of years the differences disappear.

Comparison with Civil Population.

This gross mortality must now be compared with that of the civil population. In England the gross male civil mortality at the soldier's age is—

	Mortality per 1,000 of Population.
From 20 to 25 years of age	8.83
" 25 to 35 "	9.57
" 35 to 45 "	12.48

The soldier's mortality, taken as a whole, is therefore under that of the civil population, but then there is invaliding, and some uncertain addition should be made to the mortality on this account.

Comparing the soldier's mortality (for a ten years' period, and invaliding being disregarded) with trades, he is more unhealthy than carpenters (7.77), laborers (7.92), bakers (7.94), and blacksmiths (8.36). But he is healthier than grocers (8.4), farmers (8.56), weavers and cotton-spinners (9.1), shoemakers (9.33), butchers (9.62), miners (9.96), tailors (11.62), and publicans (13.02).[2]

Influence of Age on the Mortality.

The following table gives the results:—[3]

	Per 1,000 of Strength.					
	Under 20.	20 and under 25.	25 and under 30.	30 and under 35.	35 and under 40.	40 and upward.
1870-79 (10 years)	3.11	5.08	6.18	11.64	17.28	24.09
1880	3.00	4.80	5.75	10.23	15.99	21.92
Civil male population in England and Wales	6.89	8.67	9.55	10.37	11.96	13.96
Healthy districts	5.83	7.3	7.93	8.36	8.96	9.86

[1] Army Medical Report for 1859, p. 6.

[2] Dr. Farr's numbers, in the Supplement to the 25th Report of the Registrar-General, p. 16.

[3] Army Medical Reports, vol. xxii., 1882, p. 30.

The number of soldiers under 20 years of age is so small that no conclusions can be drawn; but it would appear that from 20 to 30 the mortality is favorable to the soldier, but after that the proportion is reversed, and the soldier dies more rapidly than the civilian. And if to this we call to mind the invaliding from the army, it seems clear that a prolonged military career is decidedly injurious, either from causes proper to the career, or to personal habits engendered in it.

Causes of Mortality.

In order to see the principal causes of the eight or nine deaths which occur annually among 1,000 men, the following table has been calculated from the "Army Medical Reports":—

Causes of Mortality.[1]

	Mortality per annum per 1,000 of Strength (1867–71, 5 years).	Deaths in 100 Deaths (1867–71, 5 years).	Mortality per annum per 1,000 of Strength (1872–80, 9 years).	Deaths in 100 Deaths (1872–80, 9 years).
Phthisis and tubercular hæmoptysis	2.648	30.26	2.29	29.0
Diseases of heart and vessels	1.462	16.71	1.17	14.8
Pneumonia	.777	8.88	1.34[2]	17.0[2]
Violent deaths	.598	6.84	.61	7.7
Diseases of nervous system	.576	6.58	.54	6.8
Continued fevers, chiefly enteric	.405	4.63	.30	3.8
Suicides	.288	3.30	.21	2.7
Bronchitis	.167	1.91	..[2]	..[2]
Delirium tremens	.069	.80	..[2]	..[2]
All other causes	1.756	20.07	1.42	18.2

This table must now be analyzed more particularly.

1. TUBERCULAR DISEASES.

The deaths from phthisis and hæmoptysis in the eight years ending 1866 averaged 3.1 annually per 1,000 of strength, the highest annual ratio being 3.86, and the lowest 1.95. In 1867–71 the mean mortality was 2.648 per 1,000, in 1872–80, 2.29. In addition to this there was invaliding for phthisis, and thus a certain number of deaths were transferred from the army to the civil population. The following table shows the exact number in four branches of the service (two cavalry and two infantry) in seven years:—

[1] This table has been calculated from the numbers in the Army Med. Department Blue Books (1867–80).

[2] The abridged and incomplete form in which the statistics have been published since 1874 render it impossible to give these numbers in detail. The numbers opposite *pneumonia* for the later period include all disease of the Respiratory System—and the deaths from *delirium tremens* are included under the head of Poisons.

TABLE *to show the Deaths and Invaliding per annum from Phthisis and Hæmoptysis in Household Cavalry, Cavalry of the Line, the Foot Guards, and Infantry of the Line (mean of seven years, 1864–70).*

Phthisis and hæmoptysis, taken from Abstract in Appendix to Dr. Balfour's Report.	Household Cavalry.	Cavalry of Line.	Foot Guards.	Infantry of Line.
Died per 1,000.....	3.763	1.416	2.300	2.120
Invalided per 1,000...	8.234	4.025	9.491	5.510
Total died and invalided per 1,000.....	11.997	5.441	11.791	7.630

This table shows a considerable difference between the branches of the service; the mortality and invaliding of the household troops are much the highest. The mortality from tuberculosis of the infantry of the line is below the mean mortality of the army at large; the mortality of the cavalry of the line below that of the infantry.

It is quite clear (and the same thing is seen in the earliest records) that there has been an excessive rate of mortality and invaliding from phthisis in regiments serving in London, which points to some influences acting very injuriously upon them. During the later years, however, the invaliding in the foot guards has decreased, although the mortality has not diminished. It is remarkable that a similar excessive mortality has been observed in the guard regiments of both France and Prussia, located respectively in Paris and Berlin.[1] The following table shows the average of our own army up to 1876:—

Table similar to the one above, for 6 years, 1871–76.

Phthisis, etc.	Household Cavalry.	Cavalry of Line.	Foot Guards.	Infantry of Line.	Depots. 1873–76.
Died per 1,000.....	3.33	1.46	2.43	2.15	4.18
Invalided per 1,000. ...	4.44	4.30	7.17	4.60	9.82
Total died and invalided per 1,000.....	7.77	5.76	9.60	6.75	14.00

From this table it may be seen that up to 1876 there was a slight diminution of mortality in the household cavalry and in the infantry of the line, but that the rates were nearly stationary in the cavalry of the line and the foot guards, and very high in the depôts. In the invaliding the rates were decidedly lower in the household cavalry, the foot guards, and the infantry of the line, whilst there was a slight increase in the cavalry of the line, and the rate was high in the depôts.

Unfortunately, since 1876 this information is no longer available, it being omitted from the "Army Medical Reports."

How does this mortality compare with that of the male civil population at the soldiers' ages?

[1] Roth and Lex, op. cit., vol. iii., p. 392.

Mortality from Phthisis.

Male Civilians.[1]	Age.	
All England and Wales	20 to 25	3.5
" "	25 " 30	4.0
" "	30 " 35	4.1
" "	35 " 40	4.1
" "	15 " 55	3.7
" "	25 " 45	4.02
London	15 " 55	4.5
Worst districts in England, excluding hospitals		5.0
Best districts in England		1.96

The deaths in the army from phthisis and hæmoptysis are less than the deaths in the population generally. They are, however, on an average greater than in the best districts in England, although the rate for 1880 (viz., 1.98) was very nearly the same. But in the army there is invaliding also; that is, men with a fatal disease are discharged into the civil population. In 1880 there were invalided for tubercular disease 4.15 per 1,000, and this added to the deaths (1.98) gives 6.13 as the ratio of loss from that class of disease. Taking this into consideration, it seems certain that phthisical disease is still in excess in the army as compared with the male civil population.

Did the army suffer more from phthisis in former years than it does now? The following table will answer this question: —

Deaths from Phthisis per 1,000 *of Strength.*

	Years 1830–36, = 7 years.	Years 1837–46, = 10 years.
Household Cavalry	7.4	6.28
Cavalry of the Line	5.29	5.65
Foot Guards	10.8	11.9
Infantry	...	7.75
Mean	7.83	7.89

During these two periods, which make a total of seventeen years, the mortality was 7.86 per 1,000, and there was no decline in the later as compared with the earlier period.

But as in the 8 years ending with 1866 the mortality was only 3.1 per 1,000, in the 5 years ending 1871, only 2.6, in the 9 years ending 1880, only 2.3, and in 1880 itself under 2 per 1,000, giving for the whole period of 22 years only 2.6, there must have been an enormous excess of mortality in the earlier period, unless it can be explained in some way.

(*a*) In the earliest periods the mortality from chronic bronchitis was included in the phthisical mortality. If a correction is made for this, the mortality of the period 1859–1880 would not reach 3.0; so that will not explain the difference.

(*b*) Was the invaliding more active in the last period, so as to lessen the deaths occurring in the army below what would have taken place without invaliding? The information about the early periods is scarcely obtain-

[1] Parliamentary Return of Annual Average Mortality during the Decennial Period, 1851–60, February, 1864; and Dr. Farr's Report to the Sanitary Commission, p. 507.

able, but there seems no reason to think it was less than subsequently, but, on the contrary, it was very large from the foot guards. That invaliding cannot account for the difference is seen by the fact that the annual deaths per 1,000 in the seventeen years ending 1846 (viz., 7.86) were more numerous (in the cavalry and infantry of the line) than the average of deaths and invaliding together in the period of five years ending 1871.

(*c*) The Limited Enlistment Act, by which a certain number of weakly men may possibly have left the army, was in action in the last period. It is impossible to estimate the amount of this action, but it is in the highest degree improbable that it had much direct effect; for if a man of nearly ten years' service were ill with phthisis, he would be sure to get invalided, in order to enjoy his temporary pension for two or three years, and would not simply take his discharge.

(*d*) The lessened age of the army at large, if the Limited Enlistment Act has produced that effect, might perhaps have had some effect, as mortality from phthisis increases with age in the French army, and probably in our own; but this would never account for the astonishing difference; for in the French army the increase from phthisis of the men over fourteen years' service, as compared with those under, is only 1 per 1,000 of strength.

We may conclude, then, that there was a greater excess of the disorganizing lung diseases classed as phthisis in the earlier period (1830–46). The amount of phthisis strongly attracted the attention of Sir Alexander Tulloch and Dr. Balfour in 1839. They state that in the Equitable Assurance Company at that time the annual mortality (at the ages 20 to 40) from disease of the lungs was 3.4 per 1,000; while in the years 1830–36 the mortality from disease of the lungs among the foot guards was no less than 14.1 per 1,000, of which phthisis alone caused 10.8.[1]

How does our army contrast with others?

In France the deaths from phthisis and chronic bronchitis together amount to 2.75 per 1,000 of "present," but some die "*en congé;*" and it is probable that there is at present at least as much phthisis in the French as in our own army. In the Prussian army the men are also discharged early, so that comparison is difficult.

In the Prussian army the mean yearly mortality from laryngeal and lung phthisis was 1.28 per 1,000 of strength (years 1846–63); in 100 deaths there were 13.57. What the amount of invaliding was at that time does not appear to be recorded, but in 1868–69 it was about 3 per 1,000 of strength.[2]

We may conclude, then, with regard to phthisis—

1. That it was formerly in enormous excess in the army over the civil population, and particularly in the foot guards; in other words, a large amount of consumption was generated.

2. That there has been a great decline of late years, though there is still in all probability some excess, especially in the household troops.

What are the causes of this phthisical excess in the years 1830–46? It is noticeable that in the earlier periods all affections of the lungs were also

[1] In commenting on this fact the reporters say (Army Medical Report of 1839, p. 13)—"If the aggregation of a number of men into one apartment, even though the space is not very confined, creates a tendency to this disease, then it clearly points out the propriety of affording the soldier as ample barrack accommodation as possible." Thus, even at that time, it was seen that no other cause but overcrowding could account for the great amount of lung disease.

[2] Roth and Lex, op. cit., vol. iii., p. 391.

in excess, and we can readily see that a number of antecedents may combine in producing the result, and that destructive lung diseases may proceed from many causes. Still there must have been some predominating influence at work.

The phthisis was not owing to climate, for that is unchanged. Moreover, we shall hereafter see that the same excess was seen in the Mediterranean stations and the West Indies.

It was not owing to syphilis, for until late years the amount of syphilis has rather increased than diminished, while phthisis has lessened.

It was not owing to bad food, for the food was the same in all the branches, and yet the amount of phthisis was widely different. Besides, the food has been comparatively little altered.

It can hardly have been the duties or clothing, for there has been no sufficient change in either to account for the alteration, unless the abolition of one of the cross-belts some years ago had some effect. But then this would have only affected the infantry.

It must have been some conditions acting more on the foot guards than in the household cavalry, and less in the line regiments; also it must have been acting in the troops stationed in the Mediterranean and the West Indies. There is only one condition common to all which seems capable of explaining it, and that the cause noticed in the Report of 1839, viz., overcrowding. This condition was, and is still most marked in the barracks of the foot guards, and least in the barracks of the cavalry of the line. It is the only condition which has undergone a very decided change both at home and abroad. This consideration, as well as those formerly noticed in the section on AIR, seems to make it almost certain that the breathing the foul barrack atmosphere was the principal, perhaps the only, cause of this great mortality from lung diseases. If this be so, it shows that the foot guards are still the worst housed of any troops.

2. DISEASES OF THE HEART AND VESSELS.

The fact that diseases of the circulatory system rank second as causes of death in the army at home may well surprise us. It is marked in all arms, as much in the artillery and cavalry as in the infantry. The ratio per 1,000 of strength for the five years (1867–71) for all diseases of the organs of circulation was 1.462, and in those years out of every 100 deaths no less than 16.7 were from disease of the heart and vessels. In addition, there was a large amount of invaliding from this cause.

If the fatal diseases of the circulatory system of the five years (1867–71)[1] are divided into two classes, those referred to some disease of the heart itself (chiefly chronic), and those referred to aneurism (including an occasional rare return headed "Degeneratio Aortæ"), it is found that the deaths are :—

	Per 1,000 of Strength.	In 100 Deaths.
From cardiac disease.....	.727	8.31
From aneurism.....	.735	8.4
Total.....	1.462	16.71

These numbers are higher than those of the nine years (1859–67), when

[1] In the recent returns the differential diagnosis is not given. In the 9 years, 1872–80, the deaths per 1,000, from diseases of the circulating system, were 1.17, and the percentage of total deaths, 14.8.

the mortality from circulatory diseases was only .908 per 1,000 of strength, and the percentage on the total deaths was 9.

This mortality is in excess of that of the civil male population of the same age, especially as regards aneurism. Dr. Lawson has calculated that aneurism is eleven times more frequent among soldiers than civilians; and he has also calculated that among civilians, aged 15 to 44, the ratio of mortality from cardiac affections alone is .45 per 1,000. The army, then, in the years 1867–71, had an excess of .277 per 1,000 of heart disease. Myers' statistics are confirmatory. The amount of heart disease is greater among the foot guards than among the metropolitan policemen. Myers in his able treatise [1] gives the following numbers:—

	Died per 1,000.	Invalided per 1,000.
Foot Guards	.8	3.2
Police	.29	1.37

It is greater among soldiers than sailors; from six years' observations (1860–65) Myers [2] makes the navy mortality .66, and the invaliding 3.44 per 1,000; while in the army in the same years the mortality was .9, and the invaliding 5.26.

If the different arms of the service are taken, the following numbers are given by the five years 1867–71:—

	Cavalry of Guard.	Cavalry of Line.	Artillery.	Foot Guards.	Infantry of Line.
Mean yearly strength	1,213	8,468	9,417	5,749	31,729
Total deaths from disease of the heart in five years	1	24	57	19	73
Total deaths from aneurism in five years	2	37	49	20	103
Heart deaths per 1,000 of strength	.181	.566	1.210	.661	.460
Aneurismal deaths per 1,000 of strength per annum	.329	.873	1.041	.695	.649

The numbers in the household cavalry are so small, it is not safe to use them; but the other numbers are sufficiently large to render it probable that the artillery show a larger proportion of fatal cardiac and aneurismal cases than any other body of troops. The line cavalry and line infantry both show rather an excess of aneurismal over heart deaths; while the artillery show more heart than aneurismal deaths, and in the foot guards the proportion is equal. The point which comes out clearly from the table, in addition to the large amount in all, is the excess of both classes of deaths in the artillery; that it is a real excess is seen by comparing the yearly number of the artillery and cavalry of the line, who did not differ greatly in mean strength. The production of these diseases of the circulatory organs begins very early in the military career. In 1860–62 Dr. Parkes calculated out the causes of invaliding in 6,856 men. Of these 1,014 were under two years' service. In the whole number the percentage of heart and vessel disease as the cause of the invaliding was 7.7; among the men under two years' service it was 14.23 per cent. As these men had presumably healthy hearts when they enlisted, the effect both of the military life

[1] Diseases of Heart among Soldiers, by A. B. R. Myers, Coldstream Guards. London, 1870.

[2] Ibid., p. 11.

in producing diseases of the circulatory organs, and the greater suffering from it of young soldiers, seems certain. The statistics in the Knapsack Committee's Report confirm this.

The cause of this preponderance in the army of diseases of the circulatory organs is a matter of great importance. Whatever they may be, it is probable that they produce both the cardiac and the arterial disease.

The two most common causes of heart disease in the civil population are rheumatic fever in young, and renal disease in older persons. The latter cause is certainly not acting in the army, and the former appears quite insufficient to account for the facts. A great number of the men who suffer from heart and vessel disease have never had acute rheumatism; and if we refer the affection to slight attacks of muscular rheumatism, which almost every man has, we are certainly going beyond what medical knowledge at present warrants. The effect of lung disease in producing cardiac affections is also not seen in the army to any extent.

The influence of syphilis in producing structural changes in the aortic coats was noticed by Morgagni. In 114 post-mortem examinations of soldiers dying at Netley, Dr. Davidson[1] found 22 cases of atheroma of the aorta. Of those 17 had a syphilitic history, 1 was doubtful, and 4 had had no syphilis, but had heart and lung diseases. Of the whole 114 cases, 78 had no syphilitic history and had 4 cases of atheroma, or 5.1 per cent.; 28 had a marked syphilitic history and 17 had atheroma, or no less than 60.7 per cent. This seems very strong evidence as to atheroma. With respect, however, to actual aneurism, no corresponding analysis of cases has been made, and therefore at present the effect of syphilis must be considered uncertain; but it is quite clear, even admitting its influence, there is no reason to think that syphilis prevails more among soldiers than among the civil male population of the same class. It is, therefore, unlikely that an excess of syphilis, if it really occurs among soldiers, and if it actually predisposes to aneurism, as seems probable, could produce 11 times as many aneurisms as in civil persons. Myers has also given evidence that both in the army and navy aneurism is sometimes not preceded by degeneration of the arterial coats, and in these cases mere improper exertion seemed to produce it.

The effect of excessive smoking again has been assigned as a cause of the soldier's cardiac disease; but no one who knows the habits of many continental nations, and of some classes among our own, could for a moment believe this to be the cause.

Again, the effects of alcohol in constantly maintaining an excessive action of the heart, are so marked as to make it highly probable that this is a fact of great importance; but soldiers do not drink so much, as compared with civilians, as to lead us to think the cause can explain the prevalence.

There is, however, one cause which is continually acting in the case of soldiers, and that is the exertion (often rapid and long continued) which some of the duties involve.[2] The artillery have very heavy work; often it is very violent and sudden, more so perhaps than in any other corps; the cavalry also have sudden work at times; and the infantry soldier, though his usual labor is not excessive, is yet sometimes called upon for considerable exertion, and that not slowly, or with rests, but with great rapidity. And this exertion

[1] Army Medical Department Report, vol. v., p. 481.

[2] For a full and able discussion on all those points, and for additional evidence, reference must be made to Mr. Myers' excellent work. On the effect of exertion during war in causing cardiac hypertrophy, reference may be made to Dr. Fräntzel's paper in Virchow's Archiv, Band lvii., p. 215.

is in all arms undertaken with a bad arrangement of dress and of equipments. The cavalry and artillery men are very tightly clothed, and though the horse carries some of the burden, it is undoubted that the men are overweighted. In the infantry, till lately, they wore very tight-fitting tunics, with collars made close round the neck, and trousers (which were often kept up by a tight belt) ; there was a broad strap weighted below with a heavy pouch and ammunition, crossing and binding down the chest ; and there was the knapsack constricting the upper part of the chest, and hindering the air from passing into the proper lobes.

The production of heart disease ought not to be attributed solely to the knapsack, as is sometimes done ; the knapsack is only one agency ; the cross-belt was probably worse, and the tight clothes add their influence. But even with the knapsack alone the effect on the pulse is considerable, and one or two of Dr. Parkes' experiments may be given in illustration. Thus, four strong soldiersc arried the old regulation knapsack, service kit, great-coat, and canteen, but no pouch and no waist-belt (except in one man). The pulse (standing) before marching was on an average 88 ; after 35 minutes it had risen on an average to 105 ; after doubling 500 yards, to 139, and in one of the men was 164, irregular and unequal. After the double they were all unfit for further exertion. In a fifth man, who was not strong, the 35 minutes' marching raised the pulse from 120 to 194 ; after doubling 250 yards, he stopped ; the pulse then could absolutely not be felt. In another series, the average pulse of four men, with the knapsack only, was 98 (standing), after one hour's march, 112 ; after their doubling 500 yards, 141. If the pouch with ammunition is added, the effect is still greater. Dr. Parkes also took the pulse and respirations after long marches, and found the effect still more marked. Walking, of course, will quicken the pulse and respiration in any man, but not to such an extent, and the sense of fatigue in unincumbered men is much less.

In the lecture formerly alluded to,[1] Dr. Maclean put this matter most forcibly before the authorities, and he is undoubtedly quite justified in the expression that one cause of the cardiac (and perhaps of the aortic and pulmonary) disease in the army is to be found in exertion carried on under unfavorable conditions.

Happily, much has been lately done by the authorities to remove this cause ; but still, especially in the artillery and mounted service,[2] changes appear to be necessary, and in all arms it is desirable that officers should allow their men to do their work under the easiest conditions, as regards clothes, weights, and attitudes, consistent with military discipline and order.

3. THE NERVOUS DISEASES.

These form a very heterogeneous class ; apoplexy, meningitis, paralysis, mania, etc., are the chief headings. The proportion to 1,000 of strength is about .6, and 6.6 deaths of every 100 are owing to nervous diseases.

[1] Royal United Service Institution Journal, 1863, vol. viii.

[2] The cardiac diseases are of the most varied kind. Dr. Parkes wrote—"I have seen at Netley, in Dr. Maclean's wards, in one hour in the summer, when the hospital is full, almost all the combinations of heart affections. It has appeared to me that if anything gives the tendency to heart affections, then the dress and accoutrements come in as accessory causes, and prevent all chance of cure. In some cases there is no valvular disease, and not much hypertrophy of the heart, but a singular excitability, so that the heart beats frightfully quick on the least exertion."

As among the male civil population (ages 25 to 35) the deaths are also 6.6 per cent. of total deaths, soldiers do not appear to suffer more.

4. PNEUMONIA AND ACUTE BRONCHITIS.[1]

TABLE *to show the admissions and deaths per annum, per* 1,000 *of strength, years* 1859–71 (*thirteen years*).

	Pneumonia.		Acute Bronchitis.	
	Admissions.	Deaths.	Admissions.	Deaths.
Average	5.25	.641	55.65	.227
Highest in thirteen years	7.13	.741	88.00	.380
Lowest in thirteen years	3.49	.423	39.10	.080

The acute inflammatory diseases of the lungs give, therefore, a mean annual mortality of .856 per 1,000 of strength. The mean total deaths from diseases of the respiratory system, for the nine years (1872–80) was 1.34 per 1,000, causing 17 per cent. of total deaths.

In the French army pneumonia gives a lower, and acute bronchitis a higher, mortality than in our own, but this is perhaps a mere difference of nomenclature.

The opinion that the military suffer more than the civil population from pneumonia is an old one. It is also generally believed that they suffer less in the field than in garrison. Trustworthy statistics seem wanting as to the amount among the civil population. In the European population, generally, Ziemssen[2] gives the deaths from pneumonia as 1.5 ; and Oesterlen,[3] 1.25 per 1,000 ; but this includes all ages, and both sexes. Among men alone it is certainly greater than among women. In London, in 1865, the mortality from pneumonia, between the ages 20 and 40 (both sexes), was 1 per 1,000 population.[4]

If this be correct, the mortality among soldiers is below the civil mortality, or soldiers are less subject than civilians ; for, as men are more subject to pneumonia than women, the mortality among the civilian males would be greater than 1 per 1,000, but the military mortality is only .641. The mortality among the army pneumonic cases (deaths to treated) amounts (average of thirteen years) to 12.18 per cent.,[5] and as this is very nearly the civil proportion, every 1,000 of population in London gave nine cases of pneumonia, while 1,000 soldiers gave only five. It may be said, however, that London is not a fair test ; but as a place of residence for soldiers it does not appear to predispose to pneumonia, as will be seen from the following table :—

	Per 1,000 of Strength, years 1864-71.	
	Foot Guards in London.	Infantry in the Kingdom generally.
Admissions from pneumonia	3.75	6.06
Deaths from pneumonia	.44	.66

[1] Separate data are not published in the Army Medical Reports, for the later years.
[2] Monats-Bl. für Med. Stat., 1857, and Schmidt's Jahrb., 1862, No. 3, p. 337.
[3] Med. Statist., 2d edit., p. 567.
[4] Vacher, Sur la Mort. en 1865, Paris, 1866, p. 137.
[5] In thirteen years there were 4,826 cases treated, and 588 deaths, or 12.18 deaths per cent. In Canada the deaths to admissions were only 7.13 deaths per cent. (average of twelve years ending 1870).

The mortality to cases treated in the five years (1867–71) was, in the Guards, 10.68, and in the infantry, 11.7 per cent.

Although it does not seem that pneumonia (and acute bronchitis ?) are more common or more fatal among soldiers serving at home than among civilians, the above figures show what a fatal disease pneumonia is, and how worthy of renewed study its causes are.

5. THE CLASS OF CONTINUED FEVERS.

The returns do not carefully distinguish the several forms, but practically the majority of the fatal cases of "continued fever" are from enteric (typhoid) fever.

There has been a great decline in this class of late. In the ten years (1837–46) the average admissions were 62, and the deaths 1.72 per 1,000 of strength. In the eight years ending 1867, the admissions averaged 22, and the deaths .5 per 1,000 of strength. In 1871 there were only 80 cases of enteric fever and 22 deaths in the whole army of 87,000 men. In the four years ending 1875 the mean total deaths from continued fever were 0.37 per 1,000, and they amounted to 4.4 per cent. of the total deaths. In the five years ending 1880 the total deaths were 0.30 per 1,000, and the numbers to total deaths 4.1 ; in 1880 the numbers were respectively, 0.26 and 3.8.

This mortality is decidedly below that of the male civil population of the same age, which amounts to 9.6 per cent. of total deaths, and very nearly 1 per 1,000 of population.

During late years no points have been more attended to in the army than pure water supply and good sewerage, and we see the results in this very large diminution of deaths from the rate of the former period, and in the fact that in this particular class of disease the soldier is far better off than the civil population. So also the cholera of 1866 passed very lightly over the army at home (only 13 deaths out of 70,000 men), although in former epidemics the army suffered considerably.

The decline of enteric fevers confirms most strongly the doctrine of its intimate dependence on bad sewage arrangements.

The greatest amount of typhoid fevers in the army is in the garrisons in the seaports, the least in the camps.

The other classes of disease causing mortality need no comment. Chronic bronchitis is no doubt to be chiefly referred to phthisis (using that term as a generic word to include various disorganizing lung diseases), and delirium tremens is a return which will, no doubt, gradually disappear in fact, as it has already done in *figures* from the published Reports.

The smaller items of mortality, making up about 22 out of every 100 deaths, are various ; erysipelas, pyæmia, syphilis, hepatitis (in men from foreign service), enteritis, rheumatism (from heart complication probably, but returned as rheumatism), diabetes, ebriositas, scarlet fever, and diphtheria, are a few of the many causes which carry off a small number every year. The cancerous and kidney diseases are very few, as we might expect from the age of the men.

To sum up the case as regards the present mortality on home service, it may be stated that for the last twenty-one years (up to 1880) there has been some lessening, but no great fall in the number of deaths. There is still much to be done in respect of preventing disorganizing lung disease, disease of the circulatory organs, and even fever, for we ought not to be satisfied until the term enteric fever is altogether obliterated. A renewed study of the causes of pneumonia is also necessary, in order to see if some

way or other the attacks of that fatal disease cannot be lessened. There is no reason to think that we have yet touched the lowest possible limit of preventable disease; but, on the contrary, we can see clearly that the soldier, comparatively healthy as he is, may be made more healthy still. Some evidence in support of such a view may be found in the fact, that both at Gibraltar and in some of the West Indian stations the mortality has been lower in some years than it has ever been at home. But there is no reason why the home mortality should not be reduced to the standard of those foreign stations.

A question now arises—Why, after thirty years of age, should the soldier die more rapidly than the civilian, though for the first ten years of his service he has a smaller mortality? The causes may be foreign service, bad social habits (*i.e.*, excess of drinking and syphilis, or other effects of enforced celibacy), night duty, exposure on guard, and prolonged influence of impure barrack air. But to which of these the result is owing could only be determined by accurate statistical inquiries of the causes of mortality at the older ages. We do not know these, and if the short service system continues we are hardly likely to know them, so it is of no use to discuss a topic on which sufficient facts are not available.

B. Loss of Strength of the Army by Invaliding.

The amount of invaliding is influenced by other causes than mere inefficiency of the men; sometimes a reduction is made in the army, and the opportunity is taken to remove weakly men who would otherwise have continued to serve. This was the case in 1861. As invaliding greatly affects the mortality of the army, a source of fallacy is introduced which it is not easy to avoid.

During the seven years (1860–66), there were invalided every year nearly 37 men out of every 1,000, thus making a total loss by death and invaliding from disease of nearly 46 men per 1,000, or about one-twenty-second part of the whole force. In 1867 the invaliding was lower, viz., 22.18 per 1,000. For the ten years (1870–1879), the invaliding in the United Kingdom was at the rate of 27.18 per 1,000, and the deaths were 8.18, —making together 35.36, or one-twenty-eighth part of the force. For the whole army the numbers were, 22.15 and 12.67—together 34.82, or slightly less. In 1880 the total loss for the United Kingdom was only one-thirty-fourth, and for the whole army one-twenty-eighth. The causes of the invaliding were formerly very carefully ascertained by Dr. Balfour, and inserted in his Reports, but the information is now omitted from the "Army Medical Department Reports." Speaking in round numbers, for the period when detailed returns were furnished, phthisis and scrofula account for about one-fourth of the invalids, and if chronic bronchitis was included, for nearly seven-twentieths, the two items of hypertrophia cordis and morbus valv. cord. accounted for one-tenth, and chronic rheumatism for one-fourteenth. The three nervous diseases of amentia, mania, and epilepsy always caused a large number of invalids, amounting nearly to one-tenth, or almost the same as the two classes of heart diseases. All the other items were smaller. In men invalided under one year's service nearly one quarter were so from epilepsy; the remaining chief causes were phthisis and diseases of the circulatory organs. It is probable that the loss from invaliding will continue to diminish as a consequence of the short service system.

SECTION II.

LOSS OF SERVICE FROM SICKNESS PER 1,000 PER ANNUM.

(*a*) *Number of Admissions into Hospital.*—On an average, 1,000 soldiers furnish rather under 1,000 admissions into hospital per annum; 809.1 in ten years (1870–79). The number varies in the different arms from about 600 in the Household Cavalry and Engineers, which is usually the lowest, to about 1,100 in the Cavalry and Artillery Depôts. In the first case the steady character of the men, many of whom are married, and in the second the frequency of contusions during drill, account for this great range. In the Infantry the average is from 850 to 1,020. In 1880 the highest rate was in the cavalry, 1,016.4, and the lowest in the Royal Engineers, 587.8, the Foot Guards showing 1,003.8, and the Infantry (including depôts), 943.6.

The number of admissions remained tolerably constant for twenty-five years, but during late years has been sensibly declining.

The admissions in the French army are not comparable with ours; slight cases of sickness (which with us are often not recorded) are treated in barracks (*à la chambre*), severer, but still slight, cases in the infirmaries, bad cases in the general hospitals. The mean of five years (1862–66) gives 2,028 total admissions per 1,000 "present." The admissions to the infirmaries in France (in 1866) were 323 per 1,000 "present;" to the hospitals, 306; making a total of the severer cases of only 629 per 1,000 in that year. This shows how many slight cases there are in the French army. In the eight years (1862–69) the mean number of slight cases in France was 1,745 per 1,000 (Morache).

In the Prussian army the average admissions (mean of 18 years, 1846–63) were 1,336. In 1867 there were 1,125.6 per 1,000. In 1873–75 it was 750, and in 1876 only 620 (Roth).

(*b*) *Daily number of Sick in Hospital per* 1,000 *of Strength.*—About one-twenty-fifth of the army is constantly sick in time of peace, or 4 per cent. The mean for the ten years 1860–69 was 4.78 per cent., (or one-twenty-first part), and for the ten years 1870–79, it was 3.95 per cent., or just under one-twenty-fifth. The numbers are therefore diminishing.

It is not possible to compare the army sickness with the civil population, or even with other armies.

In England, the number of members of friendly societies, between twenty and thirty years of age, who are constantly sick, is nearly 16 per 1,000.

In the French army, the mean sick in hospital are 29 per 1,000 present; in both hospital and infirmary, 50; in the Prussian, 44 (in 1876 only 25.5); in the Austrian, 45; in the Belgian (1859), 54.2; in the Portuguese (1851–53), 39.4.

The number of daily sick has, of course, a wide range; sometimes an hospital is almost closed, at other times there may be more than 100 sick per 1,000 of strength.

(*c*) *Number of Days spent in Hospital per head in each* 1,000 *of Strength.*—The number of days' service of a battalion 1,000 strong in a year would be of course ($1{,}000 \times 365 =$) 365,000. If we assume the average number of sick to be 39½ per 1,000, there are lost to the State ($39\frac{1}{2} \times 365 =$) 14,417 days' service per annum, or 14½ days per man. As already said, it is difficult to compare the sickness of soldiers and civilians, but the above amount seems large when we remember that, in the friendly societies, the

average sickness per man per annum (under forty years of age) is less than seven days.

Mean Duration of Cases of Illness.—The number of days each sick man is in hospital (mean duration of cases) is rather greater (17.8, average of 10 years, 1870–79), as the number of admissions is below the strength.

It can be most easily calculated as follows: multiply the mean daily number of sick (sick population) by the number of days in the period, and divide by the cases treated. The number of "cases treated" is the mean of the admissions and discharges in the period.

Austrian army, 17 to 18 days.
French at home, all cases (1862–66), 7.97 days.
French in hospitals only (1862–66), 26.3 days.
French in infirmary, 12 days.
French *à la chambre*, 3.10 days.
Prussian (1859–63) in hospitals, 18.9 days.
Belgian, 23.6 days.
Portuguese, 19 days.

(*a*) *Mortality to Sickness.*—This is, of course, a different point from that of the relation of mortality to strength. A few cases of very fatal illness may give a large mortality to cases of sickness, but the mortality to strength may be very small.

The mere statement of the ratio of mortality to sickness gives little information; what is wanted is the mortality of each disease, and at every age. Otherwise the introduction of a number of trifling cases of disease may completely mask the real facts.

When, however, the general ratio is to be determined, it must be calculated in one of three ways:—

1. Mortality to admissions in the time. This is, however, an uncertain plan; a number of cases admitted toward the close of a period, and the greater part of whose treatment and mortality falls into the next period, may cause an error.

2. Mortality to cases treated (=mean of admissions and discharges).[1] This is the best method of calculation.

3. Mortality to sick population, *i.e.*, the number of deaths furnished per annum by a daily constant number of sick. This, however, must be taken in connection with the absolute number of sick in the time, and with the duration of the cases, or, in other words, with the kind of cases.

The degree of mortality to the several causes of sickness was given very fully in the statistical part of the "Army Medical Department Reports," up to the year 1873, since which time the detailed returns have been discontinued.

Calculated on the admissions, the mortality to total sickness in the

[1] It has not infrequently happened that the mortality on sickness has been calculated in this way: the number of sick remaining in hospital at the commencement of the period, say a year, are added to the admissions in the year, and the mortality is calculated on this number. At the end of the year a certain number of sick remaining in hospital are carried on to the next year, and added to the admissions of that second year for the calculation of the mortality of that year. In this way they are counted twice. This has been done in calculations of weekly mortality, and in this way the same sick man has been made to do duty as a fresh case many times over. This is to be avoided by either calculating on the admissions, or by considering half the "remaining" at the beginning to belong to the previous period, and half the "remaining" at the end of the period to belong to the following period, or, what is the same thing, taking half the admissions and half the discharges in the period as representing the "cases treated" in that time.

English army at home is a little above the mortality to strength, or about 10.2 per 1,000 per annum (1870–79). In 1880 the ratio was 7.6. In the Prussian army it was 7.25 (years 1846–62); in 1872 it was 7.7.[1]

Causes of Sickness.

The causes leading men to go into hospital are, of course, very different from those which produce mortality. For example, admissions from phthisis will be few, mortality great; admissions from skin diseases numerous, mortality trifling.

Taking the most common causes of admission in the order of frequency, we find—

1. *Venereal Diseases.*—Under the term Venereal, all diseases, immediate or remote, resulting from sexual intercourse, are included. Secondary as well as primary syphilis; stricture and orchitis, as well as gonorrhœa, etc.; also a few cases not strictly venereal. The primary venereal forms are, however, of the most importance.

In stations under the Contagious Diseases Act, 1,000 men give 67 admissions from primary venereal sores and 82 from gonorrhœa (average of 11 years 1870–80). In stations not under the Act, the amounts have been, respectively, 107 and 100. There are other admissions from secondary and tertiary syphilis, which somewhat increase the total admissions.

We have no certain facts with which we can compare the syphilitic disease of the civil population with that of the army. The amount among the civil population at large is really a matter of conjecture. But whether it is greater or less than that of the army does not affect the result drawn from the above figures, viz., that there is an appalling loss of service every year from the immediate or remote effects of venereal disease.[2]

It should be understood, also, that the action of syphilis is long continued. Many soldiers die at Netley[3] from various diseases, whose real affection has been syphilis, so that the influence of this cause is very imperfectly indicated by the number of admissions and service lost under the head of syphilitic disease only.

2. *General Diseases.*—The important diseases included under this class give about one-fourth of the total admissions, or about 199 per 1,000 (1870–80).

(*a*) Eruptive fevers are not very common, about 5 per 1,000. Smallpox is checked by vaccination; measles and scarlatina are not frequent.

(*b*) Paroxysmal fevers (most of which have been contracted out of England) give about 13 per 1,000.

(*c*) The continued fevers are more common, but their frequency is lessening. There is no doubt that typhoid is the chief, perhaps almost the only fever besides febricula which is now seen. Spotted typhus is at present uncommon, but does occasionally occur. The continued fevers cause about 20 admissions per 1,000 of strength. Of late years there have been some cases of cerebro-spinal meningitis.

[1] For numerous statistical details of foreign armies, see Roth and Lex, op. cit., vol. iii., p. 411 et seq.

[2] The order issued in 1873, directing stoppages to be made from men in hospital affected with venereal disease, was a most unfortunate one, as giving every inducement for the concealment of disease. Happily it has now been rescinded.

[3] Professors Maclean and Aitken, of the Army Medical School, are both very much impressed with the frequent occurrence of marks of continued and dominant syphilitic action in the bodies of men who die from what are considered other diseases.

(*d*) Rheumatism gives 46 cases per 1,000 of strength.

3. *Accidents* give the next greatest number; mean (1870–1880) 107; range from 65 to 114 per 1,000.

4. Diseases of the *Digestive* system follow, with nearly the same number, about 107; range from 96 to 122.

5. *Cutaneous* diseases give a mean of 104; range from 92 to 123.

6. *Respiratory* diseases (not including *Phthisis*) give a mean of 85 per 1,000; range from 76 to 103.

7. Diseases of the *Eye*, mean 16, with little variation.

8. Diseases of the *Circulatory* system, 14.

9. *Phthisis*, 13, with range between 11 and 14.

10. *Nervous* system, 12, with a range between 11 and 14.

11. The remaining diseases of numerous smaller items, such as those of the *generative* (*venereal* excluded), *locomotive*, urinary (*gonorrhœa* excluded), etc.

As almost all details of these different groups are now omitted from the "Army Medical Reports," it is difficult to discuss their causation and possible diminution.

There is no room for doubt that the venereal admissions could be greatly lessened; so also could the admissions from fever, which have in fact been already reduced from 60 to 22 per 1,000 of strength; in 1879 and 1880 they were only 16 and 17 respectively. The large class of integumentary diseases would probably admit of reduction. What is the exact nature of the phlegmon and ulcers which form so large a proportion of the admissions? Trifling as the cases are, they form a large aggregate, and a careful study of their mode of production might show how they might be diminished. Probably, however, these are mere conventional terms, under which a number of trifling cases are conveniently recorded, but a complete analysis of the returns of one year under phlegmon would be desirable. So also of all the other classes, it may be concluded that an active medical officer might succeed in reducing the cases of rheumatism, bronchitis, and dyspepsia.[1] Many cases of acute respiratory diseases are produced by exposure on guard, especially by the passage into and from the hot close air of the guard-room to the open air on sentry duty. Good additional overcoats, means of drying the clothes, and proper ventilation of the guard-rooms, would probably lessen the cases of bronchitis and pleurisy.

Sickness in Military Prisons.—The admissions into hospital in the military prisons do not appear to be great; they have varied per 1,000 of admissions of prisoners from 316 (in 1851) to 725.5 in 1863.[2] Calculated on the mean strength, the result is as follows:—In 1863, the daily average number of prisoners was 1,064; the admissions for sickness, 722; the mean daily sick, 21; the mortality, 0. These numbers give 725.5 admissions, and 19.74 mean daily sick per 1,000 of strength. Prisoners are healthier than their comrades at duty in the same garrisons where the prisoners are under sentence.

[1] It is right, however, to say that no medical officer ought to sacrifice his men in the slightest degree for the purpose of appearing to have a small sick list and an empty hospital. There is a temptation in that direction which we have to guard against, and to remember that the only question to be asked is, What is the best for the men? not, What will make the best appearance?

[2] Report on Prisons for 1863, p. 24.

SECTION III.

Such, then, being the amount of mortality and sickness at home, it may be concluded that the soldier at present is not yet in so good a condition of physical health as he might be; and we can confidently look to future years as likely to show a continuance in the improvement now going on. In future years, however, the new system of limited service will render it difficult to trace the progress in the infantry.

Health is so inextricably blended with all actions of the body and mind, that the medical officers must consider not only all physical but all mental and moral causes acting on the men under their charge.

The amount of work, the time it occupies, its relation to the quantity of food, the degree of exhaustion it produces, the number of nights in bed, and other points of the like kind; the mental influences interesting the soldier, or depressing him from *ennui;* the moral effect of cheerfulness, hope, discontent, and despondency upon his health, as well as the supply of water, air, food, clothing, etc., must be taken into account. And just as the body is ministered to in all these ways, so should there be ministration of the mind. It is but a partial view which looks only to the body in seeking to improve health; the moral conditions are not less important; without contentment, satisfaction, cheerfulness, and hope, there is no health.

Hygiene, indeed, should aim at something more than bodily health, and should indicate how the mental and moral qualities, essential to the particular calling of the man can be best developed.

How is a soldier to be made not merely healthy and vigorous, but courageous, hopeful, and enduring? How, in fact, can we best cultivate those martial qualities which fit him to endure the hardships, vicissitudes, and dangers of a career so chequered and perilous?

Without attempting to analyze the complex quality called courage,—a quality arising from a sense of duty, or love of emulation, or fear of shame, or from physical hardihood, springing from familiarity with and contempt of danger,—it may well be believed that it is capable of being lessened or increased. In modern armies, there is not only little attempt to cultivate courage and self-reliance, but the custom of acting together in masses and of dependence on others, actually lessens this. It is, then, a problem of great interest to the soldier to know what mental, moral, and physical means must be used to strengthen the martial qualities of boldness and fortitude.

The English army has never been accused of want of courage, and the idea of pusillanimity would seem impossible to the race. But drunkenness and debauchery strike at the very roots of courage; and no army ever showed the highest amount of martial qualities when it permitted these two vices to prevail.[1] In the army of Marlborough, the best governed

[1] There are many sober and excellent men in the army. But as a rule, the English soldier cannot be depended upon under any circumstances, if he can get drink. Well does Sir Ranald Martin, say, "Before that terrible vice can be overcome, something far more powerful than medical reasoning on facts, or the warnings of experience founded on them, must be brought into active operation. Discipline must still further alter its direction:—in place of being active only to punish wrong, it ought and must be exerted further and further in the encouragement to good conduct."—Ranald Martin, Tropical Climates, p. 263.

army we ever had, and the most uniformly successful, we are told that the "sot and the drunkard were the objects of scorn." To make an army perfectly brave, it must be made temperate and chaste.

Good health and physical strength, by increasing self-confidence, increase courage; and self-reliance is the consequence of feeling that, under all circumstances, we can face the dangers and difficulties that present themselves.

Few wiser words were ever written than those by William Fergusson,[1] at the close of his long and eventful service.

"Of the soldier's life within these barracks," writes Fergusson, "there is much to be said, and much to be amended. To take his guards, to cleanse his arms, and attend parade, seems to comprehend the sum total of his existence; amusement, instruction beyond the drill, military labor, and extension of exercises, would appear, until very recently, to be unthought of; as it is impossible that the above duties can fully occupy his time, the irksomeness of idleness, that most intolerable of all miseries, must soon overtake him, and he will be driven to the canteen or the gin-shop for relief.

"Labor in every shape seems to have been strictly interdicted to the soldier, as water for his drink. All, or nearly all, must have been bred to some trade or other before they became soldiers; but there is work for them no longer. Labor (the labor of field-works and fortifications) strengthens the limbs and hardens the constitution, but that is never thought of in our military life at home; so thought not the ancient Romans, whose military highways still exist, and who never permitted their soldiers to grow enervated in idleness during peace. Better, surely, would it be that every one should work at his own craft, or be employed on the public works, in regulated wholesome labor, than thus to spend his time in sloth and drunkenness. But his exercises, without even going beyond the barrack premises, may be made manifold—running, wrestling, gymnastic games of every kind, swimming, leaping, pitching the bar, the sword exercise (that of the artillery), all that hardens the muscles and strengthens the limbs, should be encouraged; and when the weather forbids out-door pastimes, the healthy exercise of single-stick, in giving balance and power to the body, quickness to the eye, and vigor to the arm, may properly be taken as a substitute for the drill which, after the soldier has been perfected in his exercise, is always felt to be a punishment. So is the unmeaning evening parade and perpetual roll-calling.

"Foot-racing too, the art of running, so little practised, and so supremely useful, should be held amongst the qualities that constitute military excellence. It was so held at the Isthmian games of ancient Greece, and deserves a better place than has hitherto been assigned to it in the military pastimes of modern Britain. In our school-books we are told that the youth of ancient Persia were taught to launch the javelin, to ride the war-horse, and to speak the truth. Let the young British warrior be taught to use his limbs, to fire ball-cartridge, to cook his provisions, and to *drink water*. The tuition may be less classical, but it will stand him in far better stead during every service, whether at home or abroad.

"Regular bodily pleasurable exercise has been said to be worth a host of physicians for preserving military health; and occupation without distress or fatigue is happiness. The philosopher can make no more of it; and every idle hour is an hour of irksomeness, and every idle man

[1] Notes and Recollections of Professional Life, 1846, p. 49.

is, and must be, a vicious man, and to a certain extent an unhealthy one."

In many of the foreign stations of the British army, excellent opportunities exist for both occupying the men and developing their spirit. All history teaches us that a hunting race is a martial one. The remarkable fighting qualities of the English, as drawn in Froissart's "Chronicles," were owing to the fact that at that time they were "a nation of hunters," and trained from infancy to face dangers alone. In India there are many places where men could not only be allowed to hunt, but where such permission would be the greatest boon to the inhabitants.

The English army has hitherto offered but few incentives to good conduct, and scanty encouragement for the cultivation of martial qualities. Men must have rewards, and feel that earnest endeavor on their part to become in all respects better soldiers is neither overlooked nor unrewarded. The new order of things introduced by Lord Cardwell seems likely to open up means of progress for men who can acquire knowledge and deserve advancement.

The cultivation of the martial qualities of the soldier is in reality a part of hygiene considered in its largest sense, but this part of hygiene must be studied and carried into effect by the combatant officers. Let us trust it may not be long before they seriously study and endeavor, by precept and example, to promote the formation of those habits of boldness and endurance, and that fertility in resources, which are as necessary as technical knowledge to render an army the formidable instrument it is capable of becoming.

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CHAPTER IV.

FOREIGN SERVICE.

The foreign service of the British army is performed in every part of the world, and in almost every latitude, and probably more than two-thirds of each line soldier's service is passed abroad. The mere enumeration of the stations is a long task; the description of them would demand a large volume. In this short chapter, to give a few general statements as to climate and geology, and the past and present medical history of the stations, only can be attempted; such an outline as may give medical officers a sort of brief summary of what seems most important to be known.

Detailed and excellent accounts of most of the foreign stations exist, either in the independent works of army surgeons, such as those of Marshall, Hennen, Davy, and many others, or in reports drawn up for Government, and published by them. In the early "Statistical Reports of the Medical Department of the Army," short topographical notices of the stations were inserted; they are models of what such reports should be, and must have been drawn up by a master in the art of condensation. In the "Annual Reports" now published many excellent topographical descriptions will be found; and some of the Indian Governments have published complete descriptions of all their stations. In the "Bombay Transactions," the *Madras Medical Journal*, and the "Bengal Indian Annals" are very full accounts of almost every station that has been, or is, occupied by European troops in India. Finally, in the "Indian Sanitary Report" is much important information on the meteorology and topography of the present Indian stations. Young medical officers first entering on foreign service are strongly advised to study these accounts of the stations in the command where they are serving; it will not only give them interest in their service, but will aid them in their search how best to meet the climatic or sanitary conditions which affect the health of the men under their charge.

SECTION I.

MEDITERRANEAN STATIONS.[1]

Gibraltar.

Usual peace garrison = 4,500 to 6,000 men. Period of service, three years. Civil population = 18,381 (in 1881). Height of rock, 1,439 feet at highest point. Nature of rock, grey limestone, with many cavities filled with reddish clay; under town, an absorbent red earth forms the subsoil.

[1] A very important Report on the Mediterranean Stations was published by the Barrack Improvement Commissioners (Dr. Sutherland and Captain Galton).—Blue Book, 1863.

Climate.—Mean temperature of year = 64.1 ;[1] hottest month, August (invariably in eight years) = 76.6 ; coldest month, either January or February, in equal proportions, 53.77 ; amplitude of the yearly fluctuation, 22.83 (= difference between hottest and coldest months).

Mean monthly maximum and minimum in shade[2]—hottest month, July or August—mean maximum = 89° ; coldest month, December, January, or February—mean minimum, 42°. Range of highest and lowest monthly means of maximum and minimum, 47°. Extreme yearly range (difference between highest and lowest temperature recorded in the time) about 50° to 58°. The minimum thermometer on grass sometimes falls to 4° or 6° below freezing.

Rainfall.—Mean, 32.8 inches (mean of seventy years, 1790–1860). Greatest amount in any one year, 75.8 (1855). Least amount in any one year, 15.1 (1800). The importance of this great variation, as regards sieges, is evident ; Gibraltar might be embarrassed for water, if the rainfall were only 15 inches in a year of siege.

Number of Rainy Days = 68. The rain is therefore infrequent, but heavy. The rain falls in nine months, September to May ; greatest amount in January and November ; most rainy days in April. Summer, rainless.

Humidity.

	Dew-point.	Grains of Vapor in a cubic foot.	Relative Humidity Sat.=100.
Mean dew-point of year	55.9°	5.75	72.3
Mean highest dew-point in August	67.9°	7.5	70.7
Lowest dew-point in January or February	43.5°	3.25	69.1

Gibraltar is thus seen to be rather a dry climate ; at any rate, the air is on an average only three parts saturated with moisture, and therefore evaporation from the skin and lungs will be tolerably rapid, provided the wind moves freely. It is certainly not a moist insular climate, as might have been anticipated. At the times of rain, however, and during the fogs and moist sirocco, the air is nearly saturated.

Winds.—Chiefly N.W. or S.W. or W., in January, April, May, June, and October. Easterly in July, August, and September. But sometimes the easterly winds are more prevalent, or may be moderate for almost the whole year. The east and south-east winds are sirocco (Levanteros), and are often accompanied by rain and fogs.

Sanitary Conditions.

Water Supply.—The *quantity* was formerly very deficient; in 1861 only 2½ gallons daily were supplied for non-commissioned officers and privates.

Sources.—Wells and tanks, rain water, and a small aqueduct carrying surface water. Very large tanks have been constructed in two of the

[1] Mean of eight years' observations by the Royal Engineers (1853–60), as given in the Barrack Commissioners' Blue Book (1863).

[2] Of the eight years (1853–60) given in the report above quoted, the difference between the monthly mean maximum and minimum is so much less in the last three years, as to make one suspect some error in observation. In 1880 the mean maximum in July was 87.4°, the mean minimum in January 47.9°—range 39.5° ; absolute maximum 98.8° in August, absolute minimum 42.5° in January—range 49.3°.

ravines, with arrangements for passing into them a large amount of surface water; and fresh wells have been dug at the north end, near the neutral ground, which yield a large supply of water.

Quality.—The most of the well water is very hard, and in some cases almost brackish. In one sample analyzed at Netley there were nearly 83 grains of chlorine per gallon, equal to nearly 140 grains of alkaline chlorides. Some of the wells contain a good deal of organic matter, while others are comparatively free. In most of them there is a large quantity of nitrates, pointing unequivocally to the oxidation of animal organic matter. Recent experimental borings have not been very encouraging as regards quality of water.[1] The tank water is good when filtered; but the tanks require frequent inspection and cleaning.

Many of the houses of the civilians have tanks, and no new house is allowed to be built without a tank. The distribution of water, both to soldiers and civilians, is defective; it is almost entirely by hand.

Drainage.—The sewers have been much improved. Surgeon-General Munro, C.B., reported in 1880 that "the system was excellent," although the working was defective. Steps were taken to remedy this.

Barracks.—More than half the garrison is in casemates, which have been described as "mere receptacles of foul air, damp, dark, and unwholesome."[2] The barracks are, for the most part, badly arranged, and are overcrowded; the average cubic space in 1862 was only about 450 feet, and the average superficial space under 40. Ventilation was very defective, especially in the casemates. The means of ablution and the latrines and urinals were also defective. In all those points, however, great improvement has taken place. The duties are not heavy, and the rations are said to be good. In 1860 some improvements were made in the dress of the troops, and a light summer suit ordered. Flannel next the skin has been recommended strongly for Gibraltar, on account of the occasional cold winds.

Health of the Civil Population.

Gibraltar is now a place of considerable trade; whether the Government have been right in allowing a mass of people to herd closely together in the midst of the most important fortress we possess, is very questionable. In case of a siege they would be a serious embarrassment, and even in time of peace they are objectionable. The health of this community is bad; in 1860, the northern district, where population is densest, gave 38 deaths per 1,000, or excluding cholera, 33.5; in the more thinly populated southern end, the mortality was 27.5 per 1,000, or more than St. Giles', in London. The deaths in children under one year form 17.33 per cent. of the total mortality. The prevailing causes of this mortality are fevers (in all probability typhoid), and tuberculous consumption, which causes 13 per cent. of the total deaths at all ages, or 37.6 per cent. of the total deaths at the soldiers' ages. Dysentery and diarrhœa are common.

In this compressed and dirty population several great epidemics have occurred. The bubo plague does not appear to have been seen since 1649, but the earlier records are very imperfect; yellow fever, however, prevailed in 1804, 1810, 1813, and 1828. Cholera has prevailed several times; the last time was in 1865.

[1] For analyses of water of Gibraltar, see Reports on Hygiene, Army Medical Reports, vols. xviii., xix., xx., and xxi.

[2] Barrack Commissioners' Report, p. 37.

Health of the Troops.

1. Loss of strength by death and invaliding.

(*a*) *By Death.*—Gibraltar has never suffered from any great sickness or mortality, except in yellow fever or cholera years. At the time when the mortality on home service was 17 or 18 per 1,000 of strength, it was usually not more than 12 at Gibraltar. Of late years both sickness and mortality have been below that of home service, especially in the latter years. In spite of this comparative healthiness, it is quite certain that much preventable disease existed, and in part still exists on the Rock.

Mortality per 1,000 *of Strength.*

Years.	Total Deaths.	Deaths from Disease alone.
1837–46 (10 years)	12.9	5.65
1861–70 (10 years)[1]	8.54	
1870–79 (10 years)	6.98	
1880	4.24	3.57

The progressive diminution is remarkable, and shows what is possible in reducing mortality among soldiers.

Causes of Death.—In the earlier years the chief causes of death were phthisis and continued fever, which was doubtless enteric fever. Of late years phthisis has declined; enteric fever, on the contrary, increased up to 1863, has since then declined in frequency, though not in fatality per cent. of attacked.

The admissions from phthisis averaged 11 per 1,000 of strength in the ten years, 1837–46; while in the eight years, 1859–66, they were only 7.63. In the years 1863–66 the deaths and invaliding together from phthisis were only 3.72 per 1,000 of strength, or hardly more than the deaths alone at home. In 1880 the admissions were 5.3, the deaths 0.45, and the invaliding 2.23. The two last together make 2.68, against 6.13 at home. The decline in phthisis seems therefore certain, but still it is possible that it is not even now so low as it might be.[2]

The continued fevers gave 75.7 admissions per 1,000 of strength in the years 1837–46, and 98.5 in the five years ending 1863. There was also an increase in mortality. In the three years ending 1866 the admissions fell to an average of 42, and the decline was progressive. Of late the admissions have increased, the numbers for 1869–78 being 77 per 1,000, in 1879 nearly 97, and in 1880 no less than 133, but of these last only 5 were enteric, the remainder being febricula and so-called Rock-fever.

During late years, much has been done in Gibraltar to give the men more breathing space and ventilation, hence the decline in phthisis which was so fatal formerly when the men were crowded in casemates. When their barracks are still further improved, we shall see a still greater lessening of phthisis.

The amount of heart disease was formerly great, and probably arose from the same conditions as at home. It has latterly diminished considerably.

[1] Cholera prevailed in 1865, and raised the mortality to 23.74. Without cholera it was 7.91.

[2] Of course invaliding has an effect, but the invalids who died at Netley are included in the above numbers.

The habits of the men are much improved, and delirium tremens, formerly common, is rare. In 1865 and 1866 only one man died in two years from this cause, or at the rate of scarcely more than .1 per 1,000 of strength.

Formerly dysentery and diarrhœa were common; now they are infrequent and mild. The average admissions from dysentery in three years (1864-66) were only 2 per 1,000; in 1864 and 1866, from diarrhœa were only 12 per 1,000.[1] In 1880 they were under 11.

Everything points to the fact that Gibraltar itself is a perfectly healthy place, and that, when the sanitary alterations now going on are completed, the sickness and mortality will be trifling.

Influence of Age on Mortality at Gibraltar.

Years.	Deaths per 1,000 of Strength at each Period.					
	Under 20.	20 and under 25.	25 and under 30.	30 and under 35.	35 and under 40.	40 and upward.
1870–79	1.57	4.04	5.59	7.29	7.51	21.71
1880		2.93	1.68	2.14	14.76	31.86

These numbers compare very favorably with the home returns.

(*b*) *By Invaliding.*—The number of men sent home for change of air and discharge varies greatly from year to year; about 20 to 30 per 1,000 of strength is the average. The chief diseases are general debility, rheumatism, phthisis, and cardiac disease. The other diseases are in smaller number, but are numerous. Dysentery and liver diseases used to be common causes of invaliding, but both are now declining.

2. LOSS OF SERVICE BY SICKNESS.

The admissions, the mean daily sick, and the duration of the cases, are all below the home standard.

Per 1,000 *of Strength.*

Years.	Admissions per Annum.	Mean daily Sick.	Mean Stay in Hospital of each Sick Man in days.
1837–56	976		
1861–70	742	36.57	18.39
1870–79	669.4	35.88	19.62
1880	738.1	43.11	21.77

The venereal diseases cause fewer admissions than at home; the average of the whole venereal class is only about 120 per 1,000. For syphilis alone the average (1869–77) is only 50.8. This is owing to the police regulation

[1] Cholera prevailed in 1865, so that year has been left out.

of prostitutes. Integumentary diseases cause about 35 admissions per 1,000. In 1880 there was a very considerable increase. Digestive disorders give a large number of admissions, and have always done so, but in the latest returns they are somewhat declining.

Sanitary Duties at Gibraltar.—Captain Galton and Dr. Sutherland indicated the measures which must be adopted, viz., a better supply of water, by arranging a larger storage; a better drainage, with sea-water for flushing, and a different outlet; and an improved ventilation, with less crowding in barracks. Most of the plans have been carried out as far as practicable. There is no doubt these measures will greatly improve health.

Supposing war were to arise at this moment, and that we lose the command of the sea for a time, the points of danger would apparently be these:—

1. *Deficient Water, the Rainfall being uncertain.*—The new wells near the neutral ground will perhaps obviate this danger, but the water is not of good quality; but if not, it would have to be supplied by distillation, and it would be prudent to keep a good apparatus always at Gibraltar. The amount of storage has been increased of late years.

2. *Overcrowding and Bad Ventilation, leading to Spotted Typhus.*—With a full garrison, and with some barracks untenable, there is no doubt there would be serious danger of this disease; and it is a matter of great moment to ventilate as perfectly as possible all casemates which, even if now disused, must be used in time of war.

3. *Typhoid Fever.*—By means of improved drainage this cause of danger might soon be entirely removed.

4. *Diseases arising in the Town, and spreading to the Garrison.*—In case of war, it would seem most desirable to clear out the native town as far as it can be done. More space and more water would be available. There would be less chance of famine, destitution, and disease.

In the war in 1792, scurvy prevailed from deficiency of food and fresh vegetables.

Malta.

Size, 17 miles by 9. Usual peace garrison = 5,000 to 7,000; period of service, three years; population (civil) in 1879 = 154,198.

Geology.—Soft, porous rock; the greater part is sandstone resting on hard limestone; in some parts there is marl and coral limestone over the sandstone. In the centre of the island, at Citta-Vecchia, there is, in order from the surface, alluvium, upper limestone, red sand, marl, sandstone, and lower limestone. Valetta is on thin alluvium, with thick sandstone below, and beneath this the lower limestone.

Climate (at Valetta).—Mean of the year,[1] 66.8°; hottest month (July), 77°; coldest (January), 57°; amplitude of the yearly fluctuation, 20°; extreme yearly range (from highest to lowest temperature in shade), 59°, from 99° in July to 40° in January; mean yearly range, about 53°.

Undulations of temperature are frequent, and there are often cold winds in winter from N.W. The south-east wind is an oppressive sirocco, raising the temperature to 94° or 95°. It is chiefly in the autumn, and blows for from 60 to 80 days every year. At Citta-Vecchia (600 feet above the sea) the temperature is lower and the air keener. Rainfall about 22 inches. Chief rain in November, December, and January; less in February and

[1] For eleven years (1869–80), with the exception of 1874, not recorded in A. M. D. Reports.

March ; small in amount in the other months. From June to August almost rainless.

Humidity (mean of 1869–80).—Observations at 9.30 A.M. Relative humidity, 70.

Malta thus appears to be a dry climate, *i.e.*, with a moderate relative humidity.

Sanitary Condition.

Much has been done of late years, and, as far as external cleanliness goes, Valetta is very clean. Water supply from rain and springs (the largest of which is in the centre of the island, and the waters of which are led by aqueduct) is not very deficient in quantity (8 to 10 gallons per head), and, except in some places, good in quality, though the rain-water contains chlorides from the spray falling on the roofs of buildings. Some of the tanks are too near the sea, which percolates into them. The tanks require, however, careful looking after. Within the lines there are 272 public and military tanks, with storage for 55 millions of gallons, and 4,294 private tanks, with storage for 323 millions of gallons. The military tanks, if full, would give 6 gallons of water per man daily for eleven months, but even now the water often falls short. The water is carried everywhere by hand, and the drinking-water for the men is not filtered, or only partially so. An attempt to get water by sinking into the sandstone was made in 1866–67, but failed. The sewers in Valetta are bad in construction and outlet, and much typhoid has been, and is still, caused in consequence. In many cases "they are nothing but long cesspools."[1] Pipe drains are, however, now being laid in the old drains, which were merely narrow deep channels cut in the soft, porous rock. The old style of drain has now quite ceased to exist in the barracks.

The barracks are bad, many casemates being used, and buildings which were intended for stores and not for habitations. They are built of soft sandstone, which both crumbles and absorbs wet. In some cases, all sanitary considerations have been sacrificed for the purposes of defence. The ventilation of the casemates is very bad, but some improvements have taken place. The Barrack Commissioners, in their "Report," recommended that in every way which could be done the ventilation should be improved by admitting the wind, especially from the north, and that each barrack would require a separate plan to meet the particular case. They recommended that air-shafts should be made, much larger than ordered for home service, viz., 1 square inch for every 20 cubic feet of space, or for a barrack of twelve men with regulation space (7,200 × 20 =) 360 square inches (= 2½ square feet) of outlet opening. Some of those points have been carried out with very good results. At the present time the amount of cubic space is below the home service amount (600 cubic feet), and the superficial area is very small, in some cases being as low as 40 square feet per head. All the barracks are now supplied with new and remodelled married quarters, with proper appliances.

During the hot weather the space is increased by making the men sleep under canvas every alternate night.[2]

A gymnasium is provided both in Cottonera and Valetta, and all the barracks are well provided with reading, recreation, and school rooms.

[1] Barrack Commissioners' Report, p. 111.

[2] Report by Surgeon-General W. A. Mackinnon, C.B., A. M.D. Reports, vol. xxii., p. 235.

The means of ablution are now very good in all the barracks, and there are new water latrines and slate or earthenware urinals provided.

We may therefore hope that a diminished amount of disease may be the result of these improvements, although much remains to be done to make the condition of the troops as good as it ought to be.

Health of the Civil Population.

There is some, but no great amount, of malarious disease, but a good deal of the so-called bilious remittent,[1] and typhoid. Typhus is not at present seen. Bubo plague has prevailed seven times, the last in 1841, slightly. Yellow fever has been known, but not of late years. Cholera has occurred thrice. Dysentery is common; tænia not infrequent; ophthalmia common, from dust and glare. Boils or anthrax are frequent; rheumatism is not uncommon, and phthisis is said to be frequent (from dust?). The death-rate is said to be 21.3 per 1,000 in the towns, and 28.7 in the country districts; while nearly 57½ per cent. of this is in children under five years,[2] the great causes of infantile mortality being registered as teething and convulsions.

Health of the Troops.

The health of the troops is worse than at Gibraltar, but it has singularly fluctuated (even without great epidemics), more so probably than at any station in the same latitude. The mortality has varied as much as three-fold without cholera.

Years.	Loss of Strength per 1,000 per annum.			Loss of Service per 1,000 per annum.		
	Total Deaths.	Deaths from Disease.	Invaliding.	Admissions.	Mean daily Sick.	Days in Hospital to each Sick Man.
1837–46	15.3			1120	43.79	
1861–70 (10 years)....	13.49		22.2	798.6	43.31	19.81
1870–79 (10 years) ...	9.77		30.00	837.8	42.35	18.45
1880.	10.02	8.80	18.01	857.1	46.56	19.88
Highest (1865, cholera)	26.44	24.63				
Lowest (1864)	6.53	4.58				

The mortality in 1864 was as low as it has ever been; but it has in former years been as low as 5.6 from disease alone. It is curious how alternations of health and sickness occur chiefly from the variations in the fevers of different kinds, especially enteric (typhoid) and the remittent or so-called Malta fever, which has a long course, a great tendency to rheumatic sequel, and little mortality.

In 1867 there was a terrible outbreak of continued fever, chiefly among

[1] See Dr. Marston's excellent Report in the Army Medical Report for 1861, for the symptoms of this disease among troops. See also Dr. Boileau's interesting essay in the same publication, vol. viii.

[2] Report of Barrack Commissioners, p. 87. The Commissioners justly remark that these figures are so striking as to demand further inquiry. Probably they are quite untrustworthy; yet both at Gibraltar and Malta, it would be of the greatest importance, not merely for the health of the troops in peace, but for the security of the fortress in war, to know everything about the social life and the diseases of the native population.

the troops quartered in the notoriously unhealthy barracks of Lower St. Elmo and Fort Ricasoli. The admissions rose to 228, and the deaths actually amounted to no less than 7.93 per 1,000 of strength. Out of 100 deaths no less than 32.2 or nearly one-third, were from "continued fever," *i.e.*, enteric fever in great measure. In 1872 there was also a great deal of fever, the admissions being 233, and the deaths 3.91, per 1,000 of strength. In 1878, also, there were 209 admissions and 5.16 deaths per 1,000 of strength, the deaths being in almost all cases enteric.

In former years phthisis was the cause of 39 per cent. of the deaths, or nearly the same as at Gibraltar. Latterly there have been fewer deaths at Malta, but a considerable number of tubercular cases are sent home. The disease is probably detected earlier, and the men do not die as formerly at the station. Still this does not account for the whole diminution, and there has been clearly a lessening of phthisis. There was formerly a large amount of stomach and bowel disease, and dysentery was forty times as frequent as in England.[1] It is certainly a very remarkable circumstance, that both at Gibralta and Malta there should have been this extraordinary liability to affections of the alimentary canal. At Malta, as at Gibraltar, it may have been chiefly owing to impure water and to food.[2] Of late years stomach and bowel affections have been less frequent, but are still more common than at home ; in 1861 the 89,000 men on home service gave only 67 cases of acute dysentery, and no deaths, while the 6,000 men at Malta had 34 cases and 2 deaths. In 1864 there were three deaths from acute dysentery among 5,654 men, while in the home stations there was only 1 death among 73,252 men. If it had been equally fatal at home, there would have been nearly 39 deaths. In the three years (1878-80) the admissions at Malta were only 4.4, and in 1880 only 2.2 per 1,000 and no deaths.

In the "Statistical Report" for 1853 it is observed that the number of cases of liver disease at Malta is remarkably high ; and the writers, while believing there must be "something in the climate of Malta peculiarly favorable to the production of hepatic affections," were unable to find, on bringing the cases into relation with the temperature, any connection. The cause of this may be something very different, and it is very desirable that the food should be looked to. There is a suspicion at Netley (which requires a few years more experience to test it), that the cases of echinococcus of the liver are more frequent in men from the Mediterranean stations than others (Dr. Maclean). The case of Iceland should lead us to look into this point.

The history of admission for venereal disease is important ; in 1837-1846, inclusive, the admissions were only 99 per 1,000, or two-thirds less than at home ; in 1859, when the next report appeared, they were 149 per 1,000 ; and in 1860 they were 147.9 per 1,000. In the early period there were police regulations, which were suspended in the two latter years. In June, 1861, the police regulations were re-enforced, and the admissions for the year sank to 102. The 4th battalion of the Rifle Brigade showed the following remarkable result : — In the first half of 1861 there were 57 admissions ; in the last half only 17. In 1862 the total number of cases of "enthetic disease" in the whole garrison were only 49.5 ; in 1863, 44 1 ; and in 1864, 53.2 per 1,000. They were increased in that year by the women who came from Ionia with the troops. In 1865 they were 44 ; in

[1] In England, in 1837–46, every 1,130 men gave one case of dysentery ; in Malta, in the same years, every twenty-eight men gave one case of dysentery. The mortality of the disease was, however, nearly the same (see pages 21 and 118 of the Report of 1853).

[2] Report of 1853, p. 118.

1866, 59.6 per 1,000. In 1870 and 1871 the admissions were very few; in the latter year, which was the worst, the admissions of primary syphilis were only 8.3 per 1,000 of strength. If the home return is looked at, it will be seen what an effect has been produced at Malta by good regulations, although the number of cases fluctuates from causes traceable to special influences; the reduction is almost entirely of syphilis, not of gonorrhœa. In the later years there has been an increase and considerable fluctuations. Such, then, in brief, seem to be the chief medical points of importance at Malta, viz., a liability to phthisis, less marked of late years; a great amount of fever, from bad sanitary conditions in great part; a liability to stomach and intestinal affections, which, though less obvious, is still great, and a singular tendency to a liver affection, which may be parasitic. The chief improvements advised by the Barrack Commissioners refer to a larger water supply, a better distribution, improved drainage, and efficient ventilation.

In the time of war, the dangers at Malta would be the same as at Gibraltar; the aqueducts might be cut by a besieging force, and the water supply restricted to the tanks.[1] Although these are supposed to hold a large quantity, they are not kept full, and could not, perhaps, be rapidly filled. The garrison might be driven to distil the sea water. A still more serious danger would be the overcrowding of a war garrison. Doubtless, in case of a war, the garrison would only be concentrated in the lines when the siege commenced, but the crowding during a siege of three or six months might be very disastrous. The danger should be provided for beforehand by a clear recognition of what accommodation would be granted for war, and how it is to be obtained without violating either the conditions of health or of defence.

On the Influence of Age on Mortality in Gibraltar and Malta.

	Deaths per 1,000 of Strength at each Period.					
	Under 20.	20 and under 25.	25 and under 30.	30 and under 35.	35 and under 40.	40 and upward.
1870–79 (10 years)..	3.72	7.76	7.65	10.41	11.96	12.18
1880.....	8.33	12.60	6.19	3.88	16.81	27.40

Cyprus.

This station was first occupied in 1878. It is an island in the Levant, about 50 miles from the nearest mainland, and 240 from Port Said at the entrance of the Suez Canal. Size, 90 miles by 40; area, about 4,000 square miles; civil population, about 185,000 (in 1881). Our information about the climate is as yet imperfect, but it appears to resemble that of Malta, with greater rainfall.

The stations at present occupied are Nicosia (592 feet above the sea), as headquarters; Polymedia camp (400 feet), by the bulk of the troops, from October to May; and Mount Troados (5,720 feet), from May to October. The average strength (1880) was 443 officers and men. The mean

[1] Dr. Notter analyzed, in 1872, fourteen of the tank waters of the different forts, and found the condition of the water to be satisfactory.

temperature at Polymedia during the cooler season (November to May inclusive) is about 59° to 60°; of Mount Troados (May to September inclusive), about 64° Fahr. The rainfall appears to be considerable, for in seven months (November to May) in 1880, 31.81 inches fell, of which no less than 12.26 were recorded in December alone. The number of rainy days in the seven months was 58. The prevailing wind would appear to be N. W.

On the first occupation in 1878 there was a great amount of sickness, chiefly from paroxysmal fever. This appeared to arise from the unsuitable sites selected for the temporary camps and the turning up of soil infiltrated with organic matter. During the five months (24th July to 31st December, 1878) there were, out of a strength of 894 non-commissioned officers and men, 3,931 admissions for disease and 36 deaths, or at the rates of 4,397 and 40.3 per 1,000 respectively. Expanding these to an annual rate, they amount to 10,094 admissions and 92 deaths per 1,000 of strength, an enormous amount. Eighty-four per cent. of the admissions and 61 per cent. of the deaths were due to fever, almost all paroxysmal (so-called remittent), only 14 admissions (actual number) and 2 deaths being due to enteric. In 1879 (strength 660) there was a great improvement—the ratios being 1,470 admissions and 21 deaths per 1,000, 35 per cent. of the admissions and 50 per cent. of the deaths being still due to paroxysmal fever. There were 3 deaths from dysentery, against 4 in 1878. In 1880 (strength 443) the total admissions were 1002.2 and the deaths only 2.26 per 1,000 strength. Paroxysmal fevers gave only 196.4 of admissions and no deaths. The only death in the command was from pulmonary extravasation, and occurred out of hospital. On the whole, we may consider the station healthy if proper precautions are taken: for, if we omit the admissions for injuries, the ratio for disease in 1880 was only 884.8 per 1,000 of strength, and of these 383.7 were venereal or the sequelæ of venereal disease. The invaliding in 1880 amounted to 18.07 per 1,000, one-fourth of which was due to syphilis; the number constantly sick was 53.27 per 1,000, of whom 4.45 were cases of injury and 28.69 venereal or its sequelæ; and the average duration of each case of sickness was 19.45 days.

The possibility of placing the troops in the hills at a considerable elevation (Mount Troados, 5,720 feet) during the hottest months, will always be a great advantage to this station.

SECTION II.

WEST INDIES.

The history of sanitary science affords many striking instances of the removal of disease to an extent almost incredible, but no instance is more wonderful than that of the West Indies. Formerly service in the West Indies was looked on as almost certain death. It is little over sixty years since the usual time for the disappearance of a regiment 1,000 strong was five years. Occasionally in a single year a regiment would lose 300 men, and there occurred from time to time epochs of such fatality that it was a common opinion that some wonderful morbid power, returning in cycles of years—some wave of poison—swept over the devoted islands, as sudden, as unlooked-for, and as destructive, as the hurricanes which so sorely plague the

"Golden isles set in the silver sea."

What gave countenance to this hypothesis was, that sometimes for months, or even for a year together, there would be a period of health so great that a regiment would hardly lose a man. But another fact less noticed was not so consistent with the favorite view. In the very worst years there were some stations where the sickness was trifling; while, more wonderful still, in the worst stations, and in the worst years, there were instances of regiments remaining comparatively healthy, while their neighbors were literally decimated. And there occurred also instances of the soldiers dying by scores, while the health of the civil inhabitants in the immediate vicinity remained as usual.

If anything more were wanted to show the notion of an epidemic cycle to be a mere hypothesis, the recent medical history of the West Indies would prove it. At present this dreaded service has almost lost its terrors. There still occur local attacks of yellow fever, which may cause a great mortality; but for these local causes can be found; and otherwise the stations in the West Indies can now show a degree of salubrity almost equalling, in some cases surpassing, that of the home service.

The causes of the production, and the reasons of the cessation, of this great mortality are found to be most simple. It is precisely the same lesson which we should grow weary of learning if it were not so vital to us. The simplest conditions were the destructive agents in the West Indies. The years of the cycles of disease were the years of overcrowding, when military exigencies demanded that large garrisons should hold the islands. The sanitary conditions at all times were, without exception, infamous.

There was a great mortality from scorbutic dysentery, which was almost entirely owing to diet.[1] Up to within a comparatively late date, the troops were fed on salt meat three, and sometimes five, days a week, and the supply of fresh vegetables was scanty. It required all the influence of Lord Howick, the then Secretary at War, to cause fresh meat to be issued, though it had been pointed out by successive races of medical officers that fresh meat was not only more wholesome, but was actually cheaper. The result of an improvement in the diet was marvellous; the scorbutic dysentery at once lessened, and the same amount of mortality from this cause is now never seen. Another cause of dysentery was to be found in the water, which was impure from being drawn from calcareous strata, or was turbid and loaded with sediment. The substitution of rain-water has sufficed in some stations to remove the last traces of dysentery.

If the food and water were bad, the air was not less so. Sir Alexander Tulloch has given a picture of a single barrack at Tobago, said to be the "best in the whole Windward and Leeward Command,"[2] the figures of which tell their own tale.

Barrack at Tobago in 1826.—Superficial space per man, 22½ feet; breadth, 23 inches; cubic space, 250 feet.

The men slept in hammocks, touching each other. In these barracks, crowded as no barracks were even in the coldest climates, there was not a single ventilating opening except the doors and windows; the air was fetid in the highest degree. With this condition of atmosphere it is impossible not to bring into connection the extraordinary amount of phthisis which prevailed in the soft and equable climate of the West Indies. There

[1] This is pointed out in the Statistical Report (1838) on the West Indies, by Tulloch and Balfour; and it is believed that the improvement in the diet was in a great measure owing to these gentlemen.

[2] Report, 1838.

was more phthisis than in England, and far more than in Canada. The first great improvement was made in 1827, when, iron bedsteads being introduced, each 3 feet 3 inches wide, greater space was obliged to be given to each man.

Every arrangement for removal of sewage was barbarous, and in every barrack sewage accumulated round the buildings and was exposed to heat and air. When yellow fever attacked a regiment, every stool and evacuation was thrown into the cesspools common to all the regiment; and in this way the disease was propagated with great rapidity, and was localized in a most singular manner, so that a few hundred yards from a barrack, where men were dying by scores, there would be no case of fever. In spite of this, it was many years before the plan of at once evacuating a barrack where yellow fever prevailed was adopted.

The barracks themselves were usually very badly constructed, and when in some cases the architects had raised the barracks on arches from the ground, in order to insure perflation of air below the buildings, the arches were blocked up or converted into store-rooms; and the barracks, with spaces thus filled with stagnant air beneath them, were more unhealthy than if they had been planted on the ground.

The localities for barracks were often chosen without consideration, or for military reasons,[1] into which no consideration of health entered. Almost all were on the plains, near the mercantile towns, where the soil was most malarious, and the climate hottest and most enervating. Malarious fevers were, therefore, common.

To all these causes of disease were added the errors of the men themselves. For the officers there existed, in the old slave times, the greatest temptation. A reckless and dangerous hospitality reigned everywhere; the houses of the rich planters were open to all. A man was deemed churlish who did not welcome every comer with a full wine, or more often a brandy, cup.

In a climate where healthy physical exertion was deemed impossible, or was at any rate distasteful, it was held to be indispensable to eat largely to maintain the strength. To take two breakfasts, each a substantial meal, was the usual custom; a heavy late dinner, frequently followed by a supper, succeeded; and to spur the reluctant appetite, glasses of bitters and spirits were taken before meals.

The private soldiers obtained without difficulty abundance of cheap rum, which was often poisoned with lead. Drunkenness was almost universal, and the deaths from delirium tremens were frequent and awfully sudden. The salt meat they were obliged to eat caused a raging thirst, which the rum-bottle in reality only aggravated.

To us these numerous causes seem sufficient to account for everything,

[1] The history of the old St. James's Barracks in Trinidad is too remarkable to be passed over. It was determined to build a strong fort—a second Gibraltar—on the lower spurs of the hills overlooking the plain where the barracks now stand. When the works had been carried on for some time, it was discovered that they could not hold the troops. The barracks were then ordered to be placed on the plain, under cover of the guns of the fort. Before the fort was quite finished, it was found to be so unhealthy that neither white nor black men could live there, and it was abandoned. The barrack, it is said, was not then commenced; yet though the reason for placing it in that spot had gone, it was still built there, on a piece of ground near two marshes (Cocorite and the Great Western Marsh), below the general level of the plain, and exposed to the winds from the gullies of the neighboring hills. Yet this bad position, so fruitful of disease, was in reality less injurious than the bad local sanitary arrangements of the old St. James's Barrack itself.

but in former days an easier explanation was given. It was held to be the climate; and the climate, as in other parts of the world besides the West Indies, became the convenient excuse for pleasurable follies and agreeable vices. In order to do away with the effects of this dreaded climate, some mysterious power of acclimatization was invoked. The European system required time to get accustomed, it was thought, to these climatic influences, and in order to quicken the process various measures were proposed. At one time it was the custom to bleed the men on the voyage, so that their European blood might be removed, and the fresh blood which was made might be of the kind most germane to the West Indies. At other times an attack of fever (often brought on by reckless drinking and exposure) was considered the grand preservative, and the seasoning fever was looked for with anxiety. The first statistical report of the army swept away all these fancies, and showed conclusively that instead of prolonged residence producing acclimatization and lessening disease, disease and mortality increased regularly with every year of residence.

The progress of years has given us a different key to all these results. It is now fully recognized that in the West Indies, as elsewhere, the same customs will insure the same results. Apart from malaria, we hold our health and life almost at will. The amount of sickness has immensely decreased; occasionally in some stations which used to be very fatal (as at Trinidad) there has not been a single death in a year among 200 men. Among the measures which have wrought such marvels in the West Indies have been—

1. A better supply of food; good fresh meat is now issued, and vegetables, of which there is an abundance everywhere.

2. Better water.

3. More room in barracks, though the amount of cubic space is still small.

4. Removal of some of the stations from the plains to the hills; a measure which has done great good, but which can explain only a portion of the improvement. The proper height to locate troops is by most army surgeons considered to be at some point above 2,500 feet.

5. Better sewage arrangements, and more attention generally to sanitary conservancy.

6. A more regular and temperate life, both in eating and drinking, on the part both of officers and men.

7. The occupancy of the unhealthy places, when retained as stations, by black troops.

8. A better dress. It is only, however, within recent years that a more suitable dress has, at the instance of the late Sir J. B. Gibson, formerly Director-General, A.M.D., been provided for the West Indian Islands.

The army stations in the West Indies are Jamaica, Barbadoes, Trinidad, St. Vincent; the last three being included in the term "Windward and Leeward Command." British Guiana, on the mainland, is part of this command. There are small parties of artillery and some black troops in Honduras and the Bahamas.

The period of service is now three or four years: formerly it was eleven or twelve, but this was altered after the first statistical report. Usually the Mediterranean regiments pass on to the West Indies, and subsequently to Canada. The total number of men serving in the West Indies is now very small.

The proper time for arriving in the West Indies is in the beginning of

the cold season, viz., about the beginning of December, when the hurricanes and autumnal rains are usually over.

JAMAICA.

Present strength of white garrison, 200 to 300; black troops, 500 to 600. Population of island estimated at 560,000. A range of lofty hills (Blue Mountains) divides Jamaica into two parts, connected by a few passes. The troops were formerly stationed chiefly in the south plains, at Kingston (30,000 inhabitants), Port Royal, Spanish Town, Up-Park Camp, Fort Augusta, etc. After the Maroon war in 1795 some troops were stationed at Maroon Town (2,000 feet above the sea) on the north side, and at Montego Bay. Subsequently Stony Hill (1,380 feet above the sea), at the mouth of one of the passes, was occupied.

Since 1842 some, and now nearly all the troops, are at Newcastle, in the hills, 4,000 feet above the sea, with detachments at Kingston and Port Royal. The other stations are now disused for white troops. The sanitary condition at Newcastle was formerly not good; the sewage arrangements are very imperfect; it is now somewhat improved.

Climate.—The climate is very different at the different stations. At Kingston (sea-level)—temperature, mean of year = 78°; hottest month, July, mean = 81°.71; coldest month, January, mean = 75°.65; mean yearly fluctuations = 6°.06. Undulations trifling. The climate is limited and equable. At Newcastle the mean annual temperature is about 66°; hottest month, August = 67°.75; coldest month, February = 61°. The diurnal range is considerable, but the annual fluctuation is trifling (about 6°). The mean of the year is therefore much lower than on the plains; the amplitude of the yearly fluctuation about the same; the diurnal change greater.

Humidity.—This is considerable in the plains—often from 80 to 90 per cent. of saturation=7 to 9 grains of vapor in a cubic foot. At Newcastle the mean yearly dew-point is about 60°; the amount of vapor in a cubic foot of air is 5.77; the mean yearly relative humidity is 68 per cent. of saturation.

Rain.—Amount on the plains = 50 to 60 inches, in spring and autumn, viz., April and May, and October and November. Showers in July and August.

Winds.—Tolerably regular land winds at night, and sea breezes in the hot and dry months during the heat of the day. The central chain of mountains turns the northeast trade wind, so that it reaches the south side diverted from its course; from December to February the wind is often from the north, and brings rain and fogs ("wet northers"). The southwest wind in April and May is very moist. The hurricane months are from the end of July to the beginning of November. The climate in the plains is therefore hot, equable, and humid.

Health of the Black Civil Population.

Of the specific diseases, small-pox and the other exanthemata are common. Spotted typhus is said to be unknown; typhoid is said to be uncommon, but is probably more common than is supposed. Influenza has prevailed at times, and also the so-called dandy or polka (Dengue). Cholera has prevailed severely. Malarious fever is common over the whole of the south plains. Yellow fever is common, though less frequent and severe among the blacks than the whites. Dysentery is common,

though it has always been less frequent than among the troops. Organic heart disease is frequent. Liver diseases are uncommon. Spleen disease, in the form of leucocythæmia, is common among the blacks (Smarda). Gout is said to be frequent, and scrofula and rickets to be infrequent. Syphilis is not common, but gonorrhœa is. Cancroid of the skin and elephantiasis of the Arabs (Pachydermia) are common. Leprosy is also seen.

Health of the Troops.

In the years 1790–93 the annual mortality of the white troops varied in the different stations from 111 (Montego Bay) to 15.7 per 1,000 of strength at Stony Hill (1,380 feet above sea-level). In the years 1794–97 the mortality was much greater; the most unhealthy regiment in the plains lost 333; the most healthy, 45.4 per 1,000 of strength; at the hill station of Maroon Town (2,000 feet) the mortality was, however, only 15.6 per 1,000. In the years 1817–36 the mean mortality was 121.3; the mean of the four healthiest years gave 67, and of the four unhealthiest years 259 per 1,000. The causes of death in these twenty years were—

Fevers	101.9	per 1,000	of strength.
Lung diseases	7.5	"	"
Bowel complaints	5.1	"	"
Brain disease	2.6	"	"
Liver diseases	1	"	"
Other complaints	3.2	"	"
	121.3	"	"

The admissions in these years were 1,812 per 1,000 of strength. In 1837–55 the following were the mean results: Mortality per 1,000 of strength—white troops, 60.8; black troops, 38.2. Admissions per 1,000 white troops, 1,371; black troops, 784. So that the mortality had declined one-half.

In 1864 the mortality was much below the home standard. In 1867 it ran up nearly to the old amount, from the prevalence of yellow fever, which in that year prevailed again in Newcastle, and caused a greater loss than it had done in 1860. The statistics of the white troops are—

Years.	Loss of Strength per 1,000 per Annum.			Loss of Service per 1,000 per Annum.		
	Total Deaths.	Deaths from Disease.	Invalids.	Admissions.	Mean Daily Sick.	Days in Hospital in each Sick Man.
1861–70 (10 years)	20.36		27.6	930.8	40.63	16.10
1871	13.51	13.51	30.4		32.43	15.17
Highest in 1867	71.09	69.80	45.91	1192.9	78.95	21.95
Lowest in 1864	7.35	5.88				
In 1875 the death rate was.	12.99					

Since 1875 no separate return is furnished in the A.M.D. Reports. An increase in admissions and mortality occurred in 1865 and 1866, owing to the exposure of the troops in the time of the negro disturbances, and their subsequent partial location on the plains.

Before this period Jamaica contrasted favorably even with home service, and particularly so with India.

A decrease of admissions in 1859–64 was chiefly owing to the comparatively small number of cases of paroxysmal disease; a decline consequent on the removal of most of the troops from the plains (in 1859 Newcastle gave 29.1 admissions, and Port Royal, on the plain, 443.5 per 1,000 of strength, from malarious disease). In 1863 some white troops were sent to Up-Park Camp, and furnished a large number of malarious cases (547.6 admissions per 1,000 of strength), while at Newcastle they were only 48 per 1,000. The decrease in the mortality in the years 1859–64 was owing to lessened fever and dysentery. Among the black troops there is now greater sickness and mortality than among the whites; the mortality in 1837–55 was 38.2 per 1,000; in 1859–65 it was 27.33; in 1866, 23.03; in 1875 it was only 14.67. There is among these troops a large mortality from paroxysmal fevers, phthisis, and diseases of the alimentary canal; and it is evident that their condition requires a close examination.

The mortality of the white troops shows a marked increase with age.

The following seem to be the most important points connected with the white troops which require notice.

It is impossible to avoid paroxysmal fevers without placing all the troops in the hills, and it is very desirable Newcastle should be made the only station for white troops.

The possibility of yellow fever occurring at an elevation of 4,000 feet was shown by the appearance of yellow fever at Newcastle in 1860 and 1867. In 1860 occurred the remarkable instances of contagion on board the ships Icarus and Imaum described by Dr. Bryson. Whether yellow fever was imported into Newcastle or not was a subject of discussion; it certainly appears probable that it was carried there; but the important point for us is that mere elevation is not a perfect security. There were, however, only a small number of cases. In 1867, when yellow fever again appeared at Newcastle, it was imported, apparently, from Kingston and Up-Park Camp.

In the returns for a number of years, cases were returned as "continued fever;" it had never been clearly made out whether or not these were cases of typhoid fever until 1873–4, when a sharp epidemic occurred at Newcastle.

Formerly there was a large number of cases of phthisis; phthisis is now uncommon; in 1817–36 lung diseases (almost entirely phthisis) caused 7.5 deaths per 1,000 of strength, or more than in England. In 1859–66 the ratio was only 1.42 per 1,000 of strength; and in 1861, out of 636 men there was not a single death, though four men were sent home with consumption. In 1865 there was no death; eight men were sent home.

At Newcastle there occurred for some years an excess of affections of the alimentary canal, chiefly indigestion; at present these have lessened, but it would be important to make out the cause. In 1860 there was not a single admission from dysentery at any station.

In the worst times in Jamaica it was always remarked that there was rather a singular exemption from acute liver disease; very few cases appear in the returns under hepatitis; whether this is a matter of diagnosis, or whether there was really an immunity compared with India or the Mauritius, is a question of great interest which cannot now be solved. At present, liver disease unconnected with drinking is uncommon.

There is still too much drinking, and the medical officers have strongly advised the issue of beer instead of the daily dram.

Venereal diseases have never prevailed much in Jamaica, they have caused, on an average, from 70 to 90 admissions per 1,000 of strength. In 1862 there were only 47 admissions per 1,000 of strength. On an average in 1859–65, enthetic diseases gave 118 admissions per 1,000. This is owing to the connection usually formed between the black women and the soldiers, and to a lessened amount of promiscuous intercourse.

The history of the years 1865–67 shows that the greatest care and the most judicious arrangement of the men is necessary to guard against a recurrence of the old evils.

The black troops gave a mortality of 24.6 per 1,000 (mean of ten years, 1861–70), especially from phthisis.

Trinidad.

Strength of garrison, 200 men. Civil population (in 1881), about 153,000.

Geology.—Tertiary formation of miocene age; central range of hills is an indurated formation of cretaceous age; the northern littoral range consists of micaceous slates, sandstones, limestones, and shales. The highest hill is 3,012 feet; the central hill (Tamana) is 1,025; one-seventeenth of the island is swampy.

Climate.—Temperature of the plains: Mean of year about 79°.3; coldest month, January = 78°; hottest month, May = 81°.5; next hottest, October = 80°.4. Mean annual fluctuation, 3°.5. The climate is therefore very equable and limited. There are, however, cold winds from the hills blowing over small areas.

Hygrometry.—Mean dew-point, 75°.1; mean relative humidity = 81 per cent. of saturation; mean weight of vapor in a cubic foot = 9.4 grains; most humid month is May, as far as the amount of vapor is concerned. Month with greatest relative humidity, August.

Winds from east to northeast and southeast. West winds rare, and oppressive.

Rain on the plains, about 60 to 70 inches. Greatest rainfall in one day, 4.67 inches. Dry season, December to May. June and July showery. Heavy rain in August, September, and October.

Sanitary Condition.—St. James's Barrack is on a depression on an alluvial soil three miles from Port of Spain, the capital; it is one mile from the Cocorite, and three from the Great Eastern Swamp; the drainage, for many years most defective, is now improved, as the main sewer is carried to the sea. On many occasions yellow fever has prevailed in this barrack, and nowhere else in the island; the last occasion was in 1858–59, and then it was proposed by Dr. Jameson (the principal medical officer) to erect barracks on a spot 2,200 feet above sea-level.

The capital, the Port of Spain (32,000 inhabitants), is built at the principal outfall of the island; it is on a low and unhealthy plain. Formerly, it was so unhealthy as to be scarcely habitable, but after being well drained and paved by Sir Ralph Woodford, it has become much healthier. This was the result of great sanitary efforts in a very unpromising locality, and should be a lesson for all climates.

There is still, however, much malarious disease, dysentery, and at times yellow fever; but this last disease has occasionally been very severe at St. James's Barracks, without a single case being seen in Port of Spain. The ascent of the malaria from the barrack plain is certainly more than 500, and probably as much as 1,000 feet.

Diseases of Troops.—The state of health has been and is very similar to that of Jamaica, with, however, a large percentage in former years both of phthisis and diseases of the stomach and bowels, chiefly dysentery.

In the years 1817–36, the average mortality of the white troops was 106.3 per 1,000 of strength, and of these deaths there were—

From fevers	61.6
Lung diseases	11.5
Diseases of stomach and bowels	17.9
Dropsies (probably partly malarious, partly renal)	7.7
Brain diseases (especially from intemperance)	4.7
Liver diseases	1.1
All other diseases	1.8
	106.3

As in Jamaica, the statistics of the white troops of late years tell a very different story.

In 1859 there was an outbreak of yellow fever, and the deaths from disease rose to 84.27 per 1,000. In the next seven years (ending 1866) the average number was 7.48 deaths from disease per 1,000. In two years (1860 and 1865) there were no deaths.

Even in 1859, when the mortality was so large, there were only 10 deaths from yellow fever among 190 men, while there were no less than 4 deaths from delirium tremens.

Among the diseases in the returns, the largest item is malarious fever; there are also cases of "continued fever," as in Jamaica; and this term, in fact, has never been absent from the reports. Is this typhoid fever? In all probability it is, as unequivocal typhoid fever does occur in Trinidad.[1] A considerable number of cases of dyspepsia are admitted; in 1860 there were 16 cases out of 221 men, or 72 per 1,000 of strength. In 1862 there were 103 per 1,000 admissions from "digestive" diseases. Venereal diseases have always been low; in 1860, 1861, 1862, and 1864, there were only 49.8, 44.4, 20.6, and 63.8 admissions per 1,000 of strength. Dysentery is now infrequent. In 1860, out of 221 men, and 1861, out of 225 men, there was not a single case. In 1864, out of 235 men, there was only 1 case. In 1865 there were no admissions from phthisis. Phthisis is much less common, yet in some years there is still too much of it. Separate statistics are no longer available from the A.M.D. Reports.

It is evident that if Dr. Jameson's suggestion is acted upon, and the troops are removed to the hills, malarious fever will disappear, and yellow fever can be prevented. In such a case, if the men will abstain from drinking, this island, which formerly killed rather more than 1 man in every 10 yearly, will be one of the healthiest spots in the world.

The black troops are now less healthy than the white, having in 1859–65 an annual mortality of nearly 20 per 1,000, of which 18 were from disease. Their condition requires looking into. Of late years a very small number of black troops have been stationed at Trinidad.

The invaliding from Trinidad is combined in the Army Reports with that of the other islands of the Windward and Leeward Command.

[1] Dr. Stone's paper in the Medical Times and Gazette, February, 1860.

Barbadoes.

Strength of garrison, 300 to 400 men. Civil population (in 1881), 172,000.

Geology.—Limestone (coralline); sandstone (tertiary); beds of bituminous matter and coal (tertiary), clay in parts (especially in the hilly district called "Scotland").

An open country, well cultivated, no marshes except a small one at Græme Hall, one mile to the east of St. Ann's Barracks.

The country is divided into two parts: a mountainous district termed "Scotland," and a lower country consisting of a series of five gigantic terraces, rising with some regularity one above the other. The highest hill is 1,100 feet.

Climate of the Plain.—Temperature: Mean of year, 80°; hottest month (October), 83°; coldest month (January),78°; mean yearly fluctuation, 5°. Climate equable and limited. Relative humidity, 70 per cent.

Wind.—N.E., trade, strongest in February to May; weak in September to November inclusive; hurricane month, August.

Rain.—About 56 to 58 inches, on an average, but varying a good deal in the autumn chiefly, though there is rain in all months, but much less. The dry season is from December to May.

Water.—Formerly supplied from wells; it was highly calcareous. At present good water is supplied by a water company. Rain-water is also collected in tanks.

Sanitary Condition.—St. Ann's Barracks are placed above one and a half mile from Bridgetown, on the sea; the locality and the construction of the barracks have been much complained of, and a position in the hills advised.[1] Arrangements for sewering and the water supply were both formerly bad; considerable improvements have been made, and, since 1862, 30,000 gallons are supplied daily to St. Ann's Barracks. It is a limestone water, containing carbonate of lime, but no sulphate of lime, and is remarkably free from organic matter. The total solids are 18.72 grains per gallon. The troops are still too much crowded in barracks, the allowance being under 600 cubic feet. Since 1872 new latrines (Jennings' pattern) have been provided and the old ones closed.

Formerly vegetables were very deficient in Barbadoes, and even now there is some difficulty in procuring them. They are often imported from other islands.

Diseases among Civil Population.—Yellow fever has appeared frequently, although the island is not marshy. It is not so frequent as formerly; it used to be expected every four years.

Barbadoes and Trinidad contrast greatly in the freedom from marshes of the one, and the existence of marshes and malarious diseases in the other; yet Barbadoes has had as much yellow fever as Trinidad.

Dysentery was common formerly, partly from bad water; influenza has been epidemic several times. Barbadoes leg, or Elephantiasis of the Arabs, is frequently seen. Leprosy, or Elephantiasis Græcorum, is also not very uncommon. Variola and Pertussis have from time to time been very bad.

Hillary, in 1766, described a "slow nervous fever," under which term

[1] For an extremely good and concise account of Barbadoes, see Dr. Jameson's Report in the Army Medical Report for 1861, p. 261.

our typhoid fever appears to have been indicated by most writers of that period. His description is not quite clear, but resembles typhoid fever more than any other. He also speaks of "diarrhœa febrilis." Can this have been typhoid?

Dracunculus was formerly very frequent, and Hillary attributes it to the drinking-water, and states that there were some ponds the water of which was known to "generate the worm if washed in or drank."

Yaws used to be common.

Colica pictonum was formerly frequent.

Diseases of Troops.—Yellow fever has several times been very fatal.

Scorbutic dysentery, arising from the wretched food, was formerly very frequent, and appears from Sir Andrew Halliday's work to have been very bad even in his time (1823 to 1832).

From 1817 to 1836 (20 years)—

Average mortality (white troops), 58.5 per 1,000 of strength.						
Greatest	"	"	204	"	"	(in 1817).
Least	"	"	18	"	"	(in 1823).

In 1817 there were 1,654 men on the island, and yellow fever broke out. In 1823 there were only 791.

Of late years, as in all the other islands, the sickness and mortality has been comparatively trifling.

In 1859–65 the total deaths were 6.98 per 1,000, and in 1866 they fell to 3.28 per 1,000, which is only one-third the mortality of home service. The highest mortality of late years was in 1862, viz., 16.77; the average number of admissions is about 1,200.

In 1864 there was an outbreak of a mild fever, termed "remittent;" the nature is unknown; no case was fatal.

The increased mortality of 1862 was owing to yellow fever. It appeared first among the civil population in Bridgetown, and afterward attacked the troops in the (stone) barracks. As it continued to spread, the men were moved out and placed under canvas, with the best effects. A remarkable feature of this epidemic was that the officers suffered in attacks six-fold more than the men, and had a mortality more than twenty-fold. The women also suffered three-fold more than the men. Formerly the case would have been reversed. In 1861 there were only two deaths out of 787 men, one from phthisis and one from apoplexy; and in 1864 there were also only two deaths (diarrhœa and phthisis) among 930 men.

Dysentery is now uncommon.

The great improvement to be made at Barbadoes is decidedly a complete change of barracks. The persistent recurrence of yellow fever in these old barracks, with their imperfect arrangements, shows them to be the main cause of the appearance of the disease. The saving in the cost of a single epidemic would amply repay the outlay.

As in the other islands, the black troops are now much more unhealthy than the white, and the sanitary condition of their barracks and their food evidently require looking into. Phthisis and chronic dysentery are the chief diseases causing mortality. The average of 1859–64 gave 1,015 admissions and 20.46 deaths per 1,000 of strength. In 1865 there were 22.64 deaths per 1,000 of strength, or, excluding violent deaths, 20.49; of these phthisis caused 14.34, or no less than 70 per cent. of total deaths.

No separate information is now available from the "Army Medical Department Reports."

St. Lucia.

Strength of garrison = 100 men, now usually black troops. Civil population (in 1871), 36,610.

St. Lucia is divided into two parts: Basseterre, the lowest and most cultivated part, is very swampy; Capisterre, hilly, with deep narrow ravines, full of vegetation. The climate is similar to that of the other islands, but is more rainy and humid.

Diseases of the White Troops.—From 1817–36; average strength, 241; average deaths, 30 = 122.8 per 1,000 of strength. Of the 122.8 deaths, 63.1 were from fevers, 39.3 from bowel disease, and 12.5 from lung disease.

Pigeon Island (a few miles from St. Lucia) was formerly so unhealthy that on one occasion 22 men out of 55 died of dysentery in one year, and of the whole 55 men not one escaped sickness. The cause is supposed to have been bad water. Now Pigeon Island is considered healthy.

Although the mortality was formerly so great, St. Lucia has been very healthy for some years.

In 1859, mean strength of white troops, 96; admissions, 113, and there was not a single death, although, if the mortality had been at the rate of the twenty years ending 1836, 12 men would have died.

Better food, some improvement in barracks, and the use of rain- instead of well-water, have been the causes of this extraordinary change.

Twenty-two men were admitted with "continued fever," 18 with ophthalmia, and only 2 with venereal.

In 1860 there was no case of dysentery and only two of diarrhœa among 100 men in this island, where formerly there would have been not only many cases, but 4 deaths. One man died from phthisis, or at the rate of 10 per 1,000.

In 1861, out of 94 men, there was one death from jaundice, or at the rate of 10.6 per 1,000.

In 1862 there were 88 men on the island; one man was drowned; there was no death from disease. No case of jaundice was admitted.

In 1863 there were 55 men, and one death from accident; there were 64 admissions, of which 15 were accidents.

The total death rate among the white troops in the West Indian Command was, in 1880, 8.68 per 1,000, of which 5.79 only were due to disease; invalids sent home, 42.43 per 1,000, of whom 12.54 were finally discharged.

British Guiana (252,000 *inhabitants in* 1881).

No white troops are at present stationed at Demerara.

This station in the West Indian Command is on the mainland, extending from the equator (nearly) to 10° N., 200 to 300 miles, and inland to an uncertain distance.

It is a flat alluvial soil of clay and sand, covered with vegetation.

The water of Georgetown is not good; it is drawn from a fresh-water lake and an artesian well; the water from this well contains a good deal of iron.

Trade-winds from N.E. an E. for nine months. In July, August, and September, S.E. and S. and land-winds. This is the unhealthy season.

Two wet seasons, January and June; the last is the longest.

Temperature of summer, 86°; of winter, 82°. Rain, about 100 inches.

Formerly there was an enormous mortality among the troops from

yellow fever and scorbutic dysentery. The men used to have salt meat five times a week.

The climate is most highly malarious, but this does not cause much mortality.

Yellow fever has prevailed here several times. On one occasion (1861) the troops were moved out and encamped at some distance from Georgetown; they escaped (7 mild cases only), although they were on a swampy plain.

In 1817–36 the average deaths were 74 per 1,000 of strength.

In 1859, out of a mean strength of 143, there were 156 admissions = 1,091 per 1,000 of strength; 2 deaths = 13.9 per 1,000 of strength. One death from apoplexy, one from drowning. The deaths from disease were only 6.9 per 1,000. Of the 156 admissions, no less than 81 were from malarious disease, or at the rate of 519 per 1,000 of strength, or nearly one-half the total admissions.

In 1860, 1861, and 1862, the admissions from malarious disease continued high (673, 1,380, and 1,104 per 1,000 of strength), the mortality was very small, being only 6.6 per 1,000 in each year; in fact, the single death in 1860 and in 1861 was in the one year from "acute hepatitis," and in the other from accident. In 1862, in spite of the immense malarious disease, there was no death.

Subsequently to 1861 it appears that scattered cases of yellow fever occurred among the shipping and in the town every year; in 1866 there was an outbreak among the white troops. In eight weeks 16 deaths occurred among 72 men, or 22 per cent.[1]

Some important lessons are drawn from the medical history of this station. It has been shown that even in a highly malarious country yellow fever may be evaded by change of ground, although the men are obliged to encamp on a swamp. Another remarkable point is the very small mortality attending the paroxysmal fevers. It would be very interesting to know the future history of such men, but it cannot be doubted that the lessened mortality since former years must be owing to better treatment.

The extent of malarious disease shows how desirable it is to avoid sending white troops to Demerara.

In French Guiana, Dr. Laure, besides malarious fevers, describes typhoid fever to have occurred for some short time after the arrival of French political prisoners after the *coup d'état* of 1851. It then disappeared.

[1] A full inquiry was made into this outbreak; it was, as so frequently happens, localized, for the troops were suffering severely, while the health officer for the port (Dr. Scott) states in his evidence (Report of the Commissioners appointed to Inquire into the Outbreak of Yellow Fever at Demerara in 1866, p. 25) that the cases in town were "very few" at the time. The barracks were badly circumstanced in various ways, particularly in having removal of sewage on a trench system, into which the latrines opened, and which trenches were intended to be kept clean by flushing; they were, however, in a very foul state, and were merely open cesspools; and the evidence of Surgeon-Major Hutton (Report, p. 37) clearly points out that a thoroughly good system of dry removal is the proper plan for this colony. Whether this and the other unsanitary conditions gave its local development to the yellow fever, was a matter of doubt in the colony; but they are precisely the same conditions which have been so frequently seen in West Indian outbreaks – a foul soil, and, in addition, open cesspools exposed to the intense heat of a tropical sun, and to the influence of a moist atmosphere and a moist soil. On this occasion the troops were not removed from the barracks until too late.

Bahamas and Honduras.

The black troops garrison both those places, and show a degree of mortality nearly the same as in the other stations, the amount of phthisis being very great. In 1862, at the Bahamas, there were no less than 4 deaths from phthisis out of a strength of 439, or at the rate of 9.1 per 1,000 of strength; there were also 3 deaths from pneumonia and 1 from pleurisy. In the years 1859–66 the average deaths from tubercular diseases per 1,000 men were 11.04 yearly, and from other diseases of the lungs, 5.86; out of 100 deaths, 60 were from diseases of the lungs. This is evidently a matter for careful inquiry.

At Honduras, among the black troops, the deaths from tubercular disease, in 1859–66, were 4.04 per 1,007 of strength.

SECTION III.

BERMUDA.

Usual strength of garrison, about 1,900 men. Civil population (in 1881), 13,948.

Climate.—Hot, equable, and rather limited.

Temperature.—Mean of year, 74°; hottest month (July), 83.5°; coldest month (February), 64.5°; amplitude of yearly fluctuation, 19°. Relative humidity about 74 per cent.

The sanitary condition was formerly very bad; there were no sewers, and no efficient dry method of removal. Now matters are much improved, and in 1875 the health of the troops was reported excellent. Rain-water is used for drinking.

Diseases of the Troops.

Years.	Loss of Strength per 1,000 per annum.			Loss of Service per 1,000 per annum.		
	Total Deaths.	Deaths from Disease.	Invaliding.	Admissions.	Mean Daily Sick.	Days in Hospital to each Sick Man.
1817–36	28.8			768		
1837–46	35.5			1080		
1861–70 (10 years)	26.02		20.6	764.3	39.54	15
1864 (highest; yellow fever year)	169.54	168.83				
1860 (lowest)	8.55	5.70				
1865–74 (10 years)	15.04		21.92	716.5	35.39	18.27
1870–79 (10 years)	8.96		20.45	637.1	32.62	18.69
1880	9.62	8.61	29.89	696.0	40.15	21.11

This history of the West Indies may be applied to Bermuda, though, with the exception of yellow fever years, it never showed the great mortality of the West Indies. There is no great amount of paroxysmal fevers; in ten years (1837–46) there were only 29 admissions out of an aggregate strength of 11,224 men. In ten years (1870–79) there were only 15 admissions out of 18,974, or at the rate of 0.8 per 1,000.

Yellow fever has prevailed seven times in this country—viz., in 1819, 1837, 1843, 1847, 1853, 1856, and 1864.

The history of the yellow fever in 1864 is given in detail by Dr. Barrow.[1]

The total mortality was 14 officers, 173 men, 5 women, and 4 children. The deaths to strength were, among the officers, 189, and among the men, 149 per 1,000. The officers' mortality was owing to a large number of deaths among the medical officers.

The town of St. George's, in Bermuda, presents every local condition for the spread of yellow fever; the town is quite unsewered; badly supplied with water; badly built.

"Dandy fever," or break-bone (Dengue), has prevailed several times.

"Continued fevers" (no doubt in part typhoid) have always prevailed more or less at Bermuda. In the ten years (1837–46) they gave 1,004 admissions out of 11,224 men, or 88 per 1,000 of strength, being much greater than at home. In ten years (1870–79) there were 884 admissions out of 18,974, or 47 per 1,000; in 1880 the ratio was 42.6.

In 1859 there were only 11 cases of "continued fever" out of 1,074 men; but in 1860 "continued fever" prevailed severely (209 cases in 1,052 men). It was of a mild type, and caused little mortality. It was probably not typhoid, but its nature has not been definitely determined. It prevailed in September, October, and November. It is said that the drainage was defective at Hamilton.

In 1866 there was decided typhoid fever, and a considerable mortality. In 1875 there were 5 admissions recorded and 1 death in 1,902 men. In 1880, 27 admissions and 6 deaths.

Formerly tuberculous diseases caused a considerable mortality. In the years 1817–36, diseases of the lungs gave a mortality of no less than 8.7 per 1,000 of strength. In 1837–46, the lung diseases gave a yearly mortality of 8.3 per 1,000 of strength. Of late years the amount has decreased. The admissions and deaths respectively were 10.5 and 2.6 in the seven years (1859–65). In 1870 the deaths from phthisis were 1.57, and in 1871 no less than 5.19 per 1,000 of strength; in 1875 they were 1.58.

Diarrhœa and dysentery were also formerly very common, but of late years there has been a great decrease. Diseases of the eyes are common.

There has always been much intemperance, and a large number of deaths from delirium tremens. This was the case even in 1866; there were no less than 5 deaths out of a total of 28.

Venereal diseases have averaged from 55 to 80 per 1,000 of strength.

In considering the sanitary measures to be adopted at Bermuda, it would seem that drainage and ventilation are still most defective, and that means should be taken to check intemperance. If yellow fever occurs, the measures should be the same as in the West Indies.

SECTION IV.

NORTH AMERICAN STATIONS.

Sub-Section I.—Canada.[2]

The usual garrison used to be from 3,000 in profound peace to 10,000 or 12,000 in disturbed times. In 1871 the troops were withdrawn from Canada and concentrated at Halifax.

[1] Army Medical Report, vol. v., p. 290.

[2] For an excellent account of the Canadian stations, see Sir W. Muir's Report in the Army Medical Report for 1862, p. 375.

Lower Canada.

Chief Stations—1. *Quebec* (62,446 *inhabitants*).

Temperature.—Mean of year, 41°; hottest month (July), 71.3°; coldest (January), 11°. Annual fluctuation, 60.3°.

The undulations of temperature are enormous. In the winter, sometimes, there is a range of 30, 40, and even more degrees in twenty-four hours, from the alternation of northerly and southerly winds. In one case the thermometer fell 70° in twelve hours. The mercury is sometimes frozen.

The mean temperature of the three summer months is 69°; winter months, 12.8°. The climate is "extreme" and variable.

Rain.—About 36 to 40 inches. The air is dry in the summer, and again in the depth of winter.

Barracks.—Built on lower Silurian rocks. No ague is known, though the lower town is damp.

Amount of cubic space small. Casemates in citadel very bad, damp, ill ventilated, ill lighted.

2. *Montreal* (140,862 *inhabitants*).

Temperature.—Mean of year, 44.6°; hottest month (July), 73.1°; coldest (January), 14.5°. Annual fluctuation, 58.6°. The undulations are very great, though not so great as at Quebec.

Mean of the three summer months, 70.8°; of the three winter months, 17.2°.

Rain.—36 to 44 inches.

Barracks.—Bad; very much overcrowded.

In Lower Canada are also many smaller stations.

Upper Canada.

Chief Stations—1. *Toronto* (86,455 *inhabitants*).

Temperature.—Mean of year, 44.3°; hottest month (July), 66.8°; coldest (February), 23.1°. Difference, 43.7°. Great undulations.

Rain.—31.5 inches.

The town stands on ground originally marshy. The new barracks are built on limestone rocks of Silurian age. Average cubic space only 350. Drainage bad.

Intermittent fevers among the civil population; not very prevalent among the troops.

2. *Kingston* (14,093 *inhabitants*).

Temperature.—Mean of year, 45.8°.

Malarious.

London, Hamilton, and several smaller stations—Fort George, Amherstberg, etc.—were also occupied at one time.

Diseases of the Civil Inhabitants.

Formerly ague was prevalent in Upper Canada, especially in Kingston; it is now much less. At Montreal ague used to be seen; now is much less frequent. It prevails from May to October, and is worst in August.

If the summer isothermal of 65° be the northern limit of malaria, both Quebec and Montreal are within the limit; yet the winter is too severe, and the period of hot weather too short, to cause much development of malaria.

The climate is in both provinces very healthy, and has been so from the earliest records, though, when the country was first settled, there was much scurvy.

Typhoid is sometimes seen. Typhus has been often carried in emigrant ships, but has not spread, or at least has soon died out. Cholera has prevailed. Yellow fever dies out. Consumption is decidedly infrequent.

Acute pulmonary diseases used to be considered the prevalent complaints, but it is doubtful whether they are much more common than elsewhere.

Diseases of the Troops.

Years 1817–36 (20 years).—Admissions per 1,000 of strength = 1,097; deaths, 16.1 (without violent deaths).

Years 1837–46 (10 years).—Yearly admissions per 1,000 of strength, 982; average daily sick per 1,000 of strength, 39.1; mortality (violent deaths excluded), 13; mortality with violent deaths, 17.42.

The mortality was made up in part of—fever, 2.13; lung disease, 7.44; stomach and bowels disease, 1.11; brain disease, 1.28. Nearly two-thirds of the fevers are returned as "common continued," probably typhoid.

Venereal admissions, 117 per 1,000.

Erysipelas was epidemic at Quebec, Montreal, and Toronto in 1841; at Montreal in 1842, from bad sanitary conditions.

The following table shows the mean of the later years:—

Years.	Loss of Strength per 1,000.			Loss of Service per 1,000.		
	By total Deaths.	By Deaths from Disease.	By Invaliding.	Admissions.	Mean Daily Sick.	Days in Hospital to each Sick man.
1861–70 (10 years	9.01		15.9	646.9	30.36	17.14
1871	9.55	5.87	17.6	679.8	33.15	17.8

Influence of Age on Mortality.

Years.	Under 20.	20–24.	25–29.	30–34.	35–39.	40 and over.
1861–70 (10 years).	3.47	6.01	9.80	11.13	17.66	20.23

These numbers show, what indeed is apparent in all the records, that Canada is a very healthy station.

The amount of phthisis was always smaller than on home service, and regiments of the Guards proceeding from London to Canada had on two occasions a marked diminution in phthisical disease.

In this respect, also, Canada contrasted formerly with the West Indies,

but of late years the decline of phthisis in the West Indies has lessened the superiority of Canada.

The comparatively small amount of phthisis was remarkable, as the troops were at times very much crowded in barracks. Latterly they had the home allowance of space (600 cubic feet).

In the later years phthisis declined considerably with improved barrack accommodation.

In the 20 years, 1817–36, the annual admissions were 6.5, and the deaths 4.22, per 1,000 of strength.

In the years 1859–65 the admissions from the whole tubercular class were 8.3, and the deaths were 1.67, per 1,000 of strength.[1] It is curious to observe that this diminution was coincident with a similar change at home.[2] The acute lung affections, pneumonia, and acute bronchitis, appear formerly to have been rather more prevalent in Canada than they were in later years.

The following table gives the mean and extremes for 8 years (1859–66):—

	Per 1,000 of Strength.	
	Admissions.	Deaths.
Pneumonia—Mean	12.24	0.8576
Highest	15.33	1.996
Lowest	7.91	0.411
Acute bronchitis—Mean	42.67	0.309
Highest	49.79	0.719
Lowest	28.48	0.092
Average of the mean of both	27.45	0.5833

If this table is compared with the similarly constructed table (at page 283), showing the prevalence of these diseases at home, it appears that both pneumonia and acute bronchitis were rather more fatal in Canada. Both together gave a mortality of .868 per 1,000 at home, and 1.166 per 1,000 in Canada. The admissions from pneumonia were also higher, but those from acute bronchitis were one-third less than at home, showing that the common catarrhal affections were less frequent in Canada. On the whole, however, the influence of the severe climate and the exposure on guard in Canada produced less effect than might have been anticipated.

"Continued fevers" (probably enteric) almost yearly gave some mortality; the mean being about .6 per 1,000 of strength. This was actually more than on home service, and depended probably on the difficulties connected with drainage. A good dry system is the only plan which can be depended on in Canada.

The great healthiness of Canada in part probably depends on the fact, that the extreme cold in winter lessens or prevents decomposition of animal matter and the giving off of effluvia; hence, in spite of bad drainage

[1] Still the lung complaints were higher than they ought to have been. Sir William Muir (Army Med. Report, vol. viii., p. 56), after detailing the measures taken by him to improve the barrack accommodation, says, "I cannot help thinking that the large number of men treated and invalided for chest disease, during the five years I have been on this command, bears a close relationship to this impure state of barrack air."

[2] In contrasting the consumptive invalidity at Gibraltar, Bermuda, and Canada, the Reporters of 1839 (Army Med. Report) remark, that the returns "afford another interesting proof how little the tendency to consumption is increased either by intensity of cold or sudden atmospherical vicissitudes." See also the remarks on Phthisis in India at a subsequent page.

and deficient water, there is no very great amount of fever. In the hot summer, the life is an open-air one. Even in winter the dry cold permits a good deal of exercise to be taken.

The amount of drunkenness and delirium tremens in Canada used to be great. In 1863 no less than 9 out of 96 deaths, or nearly one-tenth, were caused by delirium tremens. Violent deaths also are usually large, drowning giving the largest proportion.

The sickness and mortality of Nova Scotia and Newfoundland are almost identical with Canada, and they are now included in the returns under the one head of "Dominion of Canada." Both stations have always been considered very healthy. There is some typhoid fever at Halifax, and at both places there was formerly much drinking, but that is now less. In British Columbia, where there is a small garrison of 100 to 150, the health is also extremely good.

SECTION V.

AFRICAN STATIONS.

Sub-Section I.—St. Helena.

Garrison, 200. In 1880 only 194. Civil population (in 1881), 5,059.

Until comparatively recently this small island was garrisoned by a local corps (St. Helena Regiment), which has now been disbanded.

The island has always been healthy; seated in the trade-winds, there is a tolerably constant breeze from southeast. The average mortality in the years 1859–66 was 9.75, or without violent deaths, 7.85. In 1867 the mortality from disease was only 5.24. In 1875 almost the same, viz., 5.41. There is very little malarious disease (about 50 to 60 admissions per 1,000 of strength), but there has frequently been a good many cases of "continued fever," and dysentery and diarrhœa are usual diseases. Formerly there appears to have been much phthisis, but this is now much less, giving another instance of the decline of this disease, as in so many other stations.

In the years 1837–46, the admissions from tubercular diseases averaged 21 per 1,000 per annum, and the deaths 5.45. In the years 1859–66 the admissions from tubercular diseases were 6.6; and the deaths 1.66 per 1,000. In 1867 there were no admissions. The health of the troops would have been even better if the causes of the continued fever and dysentery could have been discovered and removed, and if the amount of drunkenness had been less. The returns from St. Helena are now combined with those from the Cape of Good Hope.

Sub-Section II.—West Coast of Africa.[1]

The principal stations are Sierra Leone and Cape-Coast Castle.

The station of Gambia has now been given up, and troops are no longer stationed regularly at Lagos (500 miles from Cape-Coast Castle, and occupied in 1861). In 1875 Sierra Leone, Cape-Coast, and Accra were occupied, and Elmina for a short time, and since then the two first stations have been

[1] For a very good account of the topography of the Gold Coast, see Dr. R. Clarke's paper in the Transactions Epid. Society, vol. i.

alone garrisoned. No white troops are employed, except during war-time, as in the Ashanti campaign of 1873.

Sierra Leone.

Strength of garrison, 300 to 500 black troops, with a few European officers and non-commissioned officers. Civil population (in 1872), 37,089. Hot season from May to the middle of November; Harmattan wind in December; soil, red sandstone and clay, very ferruginous. There are extensive mangrove swamps to N. and S. Water very pure. The spring in the barrack square contains only 3 to 4 grains per gallon of solids.

This station had formerly the reputation of the most unhealthy station of the army. Nor was this undeserved.

From 1817 to 1837 (twenty years) there were yearly among the troops—

Admissions.....	2,978 per 1,000
Deaths	483 "

At the same time, about 17 per cent. of the whole white population died annually.

The chief diseases were malarious fevers, which caused much sickness, but no great mortality; and yellow fever, which caused an immense mortality. Dysentery, chiefly scorbutic, was also very fatal.

The causes of this great mortality were simple enough. The station was looked upon as a place of punishment, and disorderly men, men sentenced for crimes, or whom it was wished to get rid of, were drafted to Sierra Leone. They were there very much overcrowded in barracks, which were placed in the lower part of the town. They were fed largely on salt meat; and being for the most part men of desperate character, and without hope, they were highly intemperate, and led, in all ways, lives of the utmost disorder. They considered themselves, in fact, under sentence of death, and did their best to rapidly carry out the sentence.

Eventually, all the white troops were removed, and the place has since been garrisoned by one of the West Indian regiments. Of late years, the total white population of Sierra Leone (civil and military) has not been more than from 100 to 200 persons.

The great sickness and mortality being attributable, as in so many other cases, chiefly to local causes and individual faults, of late years Europeans have been comparatively healthy; although from time to time fatal epidemics of yellow fever occur. They are, however, less frequent and less fatal than formerly. The position of the barracks has been altered, and the food is much better. One measure which is supposed to have improved the health of the place, is allowing a species of grass (Bahama grass) to grow in the streets. The occupiers of the adjacent houses are obliged to keep it cut short, and in good order.

During the four years, 1863–66, there died 8 white non-commissioned officers, in the whole command of the West Coast, out of an average strength of 25, or at an annual rate of 80 per 1,000 of strength. Three of the 8 deaths were from liver disease, two from delirium tremens, two from fevers, and one from dysentery. In 1867 two sergeants died, out of 15 white men—one from apoplexy, one from delirium tremens.

Among the black troops serving in Sierra Leone and the Gold Coast, the returns of the ten years (1861–70) give 1,283 admissions and 22.49 deaths per 1,000. In 1871 the deaths were 15.63 per 1,000 from disease.

In ten years (1870–79) the admissions were 1640.5 and the deaths 25.07 per 1,000. 1873 was the year of the last Ashanti war. In 1880 the admissions were 1565.7 and the deaths 22.47, of which 20.86 were from disease. These numbers are for the whole West African command. Among the causes of death, tubercular diseases hold the first place, amounting to 7.05 per 1,000 of strength. In 1862 phthisis amounted to no less than 12.6 per 1,000 of strength, and constituted 43.7 per cent. of all deaths from disease. There were also 9.46 per 1,000 of strength deaths from pneumonia. In 1863 the deaths from phthisis were 9.3 per 1,000 of strength, and made up 36.3 per cent. of the total deaths. In 1867 the tubercular deaths per 1,000 of strength were 17.71 in Sierra Leone, 15.87 at the Gambia, and 12.58 at the Gold Coast and Lagos together. In 1880 the total rate for the command was 11.23 per 1,000. It seems clear, indeed, that in all the stations of the West Indian corps (black troops), the amount of phthisis is great; in fact, the state of health generally of these regiments requires looking into, as in the West Indies.

In 1862 there were only five cases of intermittent, and eighteen of remittent fever among 317 negroes. In 1880 the number was 404 out of 623.

In 1861 some of the troops from Sierra Leone and the Gambia were employed up the Gambia against the Mandingoes, and also against the chiefs of Quiat. In 1863 and 1864, and again in 1873, Ashanti wars prevailed. All these wars added to the sickness and mortality, so that these years are not fair examples of the influence of the climate.

Gambia.

No troops have been quartered here of late years, and it has been in contemplation to abandon the station. It is much more malarious than any of the others. The drinking water is bad; all barrack and sewage arrangements are imperfect. Yellow fever from time to time is very destructive. In 1859 two out of four European sergeants, and in 1860 three medical officers, died of yellow fever. Among the black troops in 1859–65, the admissions were 1169.8 and the deaths 29.97 per 1,000 of strength.

As at Sierra Leone, phthisis and other diseases of the lungs caused a large mortality among the negroes. In 1861 phthisis gave five deaths out of a strength of 421, or at the rate of 11.6 per 1,000 strength; and pneumonia gave four deaths, and acute bronchitis three, or (together) at the rate of 16.24 per 1,000 of strength. Phthisis, pneumonia, and bronchitis gave nearly 60 per cent. of all deaths from disease. This was higher than in previous years; but in 1862 phthisis gave 14.35 deaths per 1,000 of strength, and constituted 75 per cent. of the whole number of deaths. There was, however, no pneumonia or bronchitis in that year. In 1856 the tubercular class gave 9.53 deaths per 1,000. In 1863, however, there were no deaths from phthisis. Although the period of observation is short, it can hardly be doubted that here, as elsewhere in the stations occupied by the West Indian regiments, some causes influencing the lungs prejudicially are everywhere in action. It is probably to be found in bad ventilation of the barracks.

Among the few white residents at the Gambia, diarrhœa, dysentery, and dyspepsia appear to be common. These, in part, arise from the bad water; in part from dietetic errors (especially excess in quantity), and want of exercise and attention to ordinary hygienic rules.

Cape-Coast Castle (*Gold Coast*).

Garrison, 300 to 400 (black troops).

This station has always been considered the most healthy of the three principal places. It is not so malarious as even Sierra Leone, and much less so than the Gambia, and has been much less frequently attacked with yellow fever. Dysentery and dyspepsia are common diseases among the white residents. Among the black troops the prevalence of phthisis, pneumonia, and bronchitis is marked, though less so, perhaps, than at the other two stations.

One peculiarity of the station was the prevalence of dracunculus. This was much less common at Sierra Leone, and at the Gambia. It appears to have lessened considerably in later years, but there is no definite information now to be obtained from the A. M. D. Reports.

Hygiene on the West Coast.

There is no doubt that attention to hygienic rules will do much to lessen the sickness and mortality of this dreaded climate. In fact, here as elsewhere, men have been contented to lay their own misdeeds on the climate. Malaria has, of course, to be met by the constant use of quinine during the whole period of service. The other rules are summed up in the following quotation from Dr. Robert Clarke's paper,[1] and when we reflect that this extract expresses the opinion of a most competent judge on the effect of climate, we must allow that, not only for the West Coast, but for the West Indies, and for India, Dr. Clarke's opinions on the exaggeration of the effect of the sun's rays and exposure to night air, and his statement of the necessity of exercise, are full of instruction :—

"Good health may generally be enjoyed by judicious attention to a few simple rules. In the foremost rank should be put *temperance*, with regular and industrious habits. European residents on the Gold Coast are too often satisfied with wearing apparel suited to the climate, overlooking the fact that exercise in the open air is just as necessary to preserve health there as it is in Europe. Many of them likewise entertain an impression that the sun's rays are hurtful, whereas in nine cases of ten the mischief is done, not by the sun's rays, but by habits of *personal economy*. Feeling sadly the wearisome sameness of life on this part of the coast, recourse is too frequently had to stimulants, instead of resorting to inexhausting employments, the only safe and effectual remedy against an evil fraught with such lamentable consequences. Europeans also bestow too little attention on ventilation, far more harm being done by close and impure air during the night than is ever brought about by exposure to the night air.

"Much of the suffering is occasioned by over-feeding."[2]

[1] Trans. of the Epidem. Soc., vol. i., pp. 123, 124.

[2] Considerable interest in this part of the work was roused by the occurrence of the Ashanti war of 1873, for an admirable account of which see the Army Medical Reports, vol. xv., where Sir Anthony D. Home gives a full medical history of the operations carried on. The excellent hygienic arrangements enabled the arduous work of the expedition to be accomplished with a comparatively small loss. But the few casualties in action, compared with the deaths by disease, show by contrast how much more deadly were the forces of nature than those of the enemy: 26 officers died, of whom only five were killed or died of wounds; 13 men were killed (white troops), while 40 died of disease; of the West Indian troops (black) only 1 was killed, while 41 died of disease. For analysis of soil of Gold Coast, see Army Med. Reports, vol. xiv., p. 264; and for some account of the drinking-water, see paper by Dr. J. D. Fleming, in vols. xiv. and xv.

Sub-Section III.—Cape of Good Hope.

Garrison, about 3,000 men.

The chief stations are Cape Town (about 45,000 inhabitants), Graham's Town, King William's Town, Port Elizabeth, Algoa Bay, and several small frontier stations. At Natal there is also a small force. The climate is almost everywhere good; the temperature is neither extreme nor very variable; the movement of air is considerable.

At Cape Town the mean annual temperature is 67°, with a mean annual range of about 38°.

Years.	Total Deaths.	Admissions.	Mean daily Sick.	Days in Hospital to each Sick Man.
1860–69 (10 years).....	10.87	973	50.24	18.83
1870–77 (8 years)[1].....	9.72	906	43.85	17.88

The statistics of later years are complicated by the casualities of war, included killed and wounded in action and a great excess of fever. Eliminating these, we have the following ratios per 1,000:—

Years.	Total Admissions.	Wounds and Injuries.	Admissions for Disease only	Continued Fever.	Paroxysmal Fever.	Admissions for Disease, excluding Fevers.
1870–77 (8 years of peace).....	906	131	775	39	28	708
1878–80 (3 years of war).....	900	103	797	159	38	600

Deaths per 1,000 *of Strength.*

Years.	Total.	Wounds and Injuries and Killed in Action.	Disease only.	Continued Fever.	Paroxysmal Fever.	Deaths from Disease, excluding Fevers.
1870–77 (8 years).....	9.72	1.94	7.78	0.50	0.24	7.04
1878–80 (3 years).....	50.43	28.98	21.45	11.16	1.13	9.18

As regards the admissions, which in total number appear little if at all influenced by war, it is clear that the diminution which might have been expected in consequence of sanitary improvements was chiefly arrested by the great number of cases of continued fever, which occurred during the period of hostilities. In times of peace there is but little fever, and a small and decreasing mortality. Thus, in 1856–66, the death-rate was 1.25 per 1,000, in 1870–77 only 0.50,—while in 1878–80 it was no less than 11.16; in all these cases the deaths are almost invariably enteric. Paroxysmal fevers, arising in the station itself, are very uncommon, the worst year in the period 1870–77 being 1874, when these diseases appeared among troops

[1] Including the detachment at St. Helena.

from the Mauritius, where it had undoubtedly been contracted. During the period of hostilities there was an increase both in admissions and deaths from that cause. Although the net admissions (after eliminating wounds and injuries and fevers) are less in the later period (1878–80) than in the earlier (1870–77), as shown in the preceding table, yet the death-rate is higher. This is almost entirely due to diseases of the digestive system, mostly dysentery and diarrhœa. These were more common formerly than they are now in ordinary years; in many cases, especially in the small frontier stations, they were clearly owing to bad water.

Ophthalmia has prevailed rather largely, especially in some years; there is a good deal of dust in many parts of the colony, and it has been attributed to this; the disease is probably the specific ophthalmia (gray granulations), and is propagated by contagion. Whether it had its origin in any catarrhal condition produced by the wind and dust, and then became contagious, is one of those moot points which cannot yet be answered.

The Cape has always been noted for the numerous cases of muscular rheumatism. Articular rheumatism is not particularly common. There is also much cardiac disease. The prevalence of this affection has been attributed to the exposure and rapid marches in hill districts during the Kaffir wars. In 1863 there was, however, less rheumatism than usual.

Taking the years 1859–66 as expressing tolerably fairly the effect, *per se*, of the station, we find that the whole colony gave 18.3 admissions and 1.90 death per 1,000 of strength from diseases of the circulatory organs. In 1869–77 the admissions were 13.5 and the deaths 1.47; in 1878–80 they were 20.3 and 1.25 respectively.

Dr. Lawson[1] has contributed a valuable paper on this subject. He finds the death-rate from diseases of the organs of circulation (mean of seven years, 1859–65) at 1.91 per 1,000 of strength. This is higher than at any other foreign station, as will be seen from the table copied by Dr. Lawson.

Mortality from Diseases of the Circulatory Organs.

	Ratio per 1,000 of Strength.		Ratio per 1,000 of Strength.		Ratio per 1,000 of Strength.
Cape of Good Hope,	1.91	Bombay	0.80	Malta	0.53
New Zealand	1.18	Bengal	0.86	Gibraltar	0.70
Australia	1.72	South China	1.16	Bermuda	1.25
Mauritius	0.53	West Indies	1.02	Nova Scotia	0.84
St. Helena	0.31	Jamaica	0.85	Canada	1.19
Ceylon	1.11	Ionia	0.84	Home	0.93
Madras	1.12				

This table shows an extreme diversity, hardly to be reconciled with differences of climate or duties. In the years 1869–74 the death-rate was 1.68, and was exceeded by that of the Mauritius, 2.29, and that of Madras, 1.99. In 1875 the rate at the Cape was only 1.45, while Ceylon showed 3.87, Bermuda 2.63, and Madras 2.05; Mauritius returning no death. In the eight years (1870–77) the rate at the Cape was 1.62; and in the years 1878–80 it was 1.25.

Scurvy formerly prevailed much at the Cape, particularly in the Kaffir wars, and may have had something to do with the prevalence of dysentery.

[1] Army Medical Report, vol. v., p. 338.

Venereal diseases have of late years been very common. The average admissions from "enthetic" diseases in 1859–66 were 248.5, and in 1867 they were 438.3 per 1,000 of strength in the whole colony. In Cape Town alone, where facilities for promiscuous intercourse are greater, they were even more numerous.[1] Much diminution has taken place in recent years. In the ten years, 1871–80, the ratio for syphilis, both primary and secondary, was only 102, and for gonorrhœa 80.

The Cape has always been considered a kind of sanitarium for India. Its coolness and the rapid movement of the air, the brightness and clearness of the atmosphere, and the freedom from malaria, probably cause its salubrity. It has been supposed that it might be well to send troops to the Cape for two or three years before sending them on to India. This plan has never been perfectly tried; but in the case of regiments sent on hurriedly to India on emergency, it has been said that the men did not bear the Indian climate well. Probably they were placed under unfavorable conditions, and the question is still uncertain.

As a convalescent place for troops who have been quartered in a malarious district it is excellent.[2]

SECTION VI.

MAURITIUS.

Garrison, about 300 to 500 men. Civil population (in 1879), 359,988.

Mauritius in the eastern has been often compared with Jamaica in the western seas. The geographical position as respects the equator is not very dissimilar; the mean annual temperature (80° Fahr.) is almost the same; the fluctuations and undulations are more considerable, but still are not excessive; the humidity of air is nearly the same, or perhaps a little less; the rainfall (66 to 76 inches) is almost the same; and the physical formation is really not very dissimilar. Yet, with all these points of similarity in climatic conditions, the diseases are very different.

Malarious fever was formerly not nearly so frequent as in Jamaica, and true yellow fever is quite unknown; Mauritius, therefore, has never shown those epochs of great mortality which the West Indies have had. Hepatic diseases, on the other hand, which are so uncommon in the West Indies, are very common in the Mauritius. For example, in 1859 there were 47 cases of acute and chronic hepatitis in 1,254 men, while in Jamaica there was one case out of 807 men. In 1860 there were 31 admissions from acute hepatitis out of 1,886 men; in Jamaica there was not a single case. In 1862 there were 12 cases of acute, 11 of chronic hepatitis, and 72 cases of hepatic congestion, out of 2,049 men; in Jamaica, in the same year, there was only 1 case of acute hepatitis out of 702 men. This has always been marked; is it owing to an error in diagnosis or to differences in diet? It can scarcely be attributed to any difference in climate. In 1863 the difference was less marked, but was still evident. In later years, however, there has been considerable diminution: in 1872 there were only 4 cases of hepatitis, and in 1873 only 2. Since that year no detailed statistics have been published, but it is mentioned incidentally that there were 3 cases in 1880, out of a strength of 353.

[1] Army Med. Depart. Report, vol. viii., p. 548.

[2] See effect on the 59th Regiment in the Army Medical Report for 1859, p. 99.

In 1866–67 a very severe epidemic fever prevailed in the Mauritius, which offers many points of interest. As already noted, the Mauritius has till lately been considered to be comparatively free from malaria. All the older writers state this, and it is apparent from all the statistical returns. Deputy Inspector-General Dr. Francis Reid, in a report[1] in 1867, mentions that he had served ten years in the Mauritius, and had looked over the records of the troops for twenty-four years. He found some records of intermittents, but he traced all these to foreign sources, viz., troops coming from India, China, or Ceylon, and presenting cases of relapses.

For the first time, in the latter months of 1866 and the commencement of 1867, malarious fevers of undoubted local growth appeared on the western side of the island.

The causes of this development were traced by Dr. Reid, and also by Surgeon-Major Small and Assistant Surgeon W. H. T. Power, in some very careful Reports.[2] During some years a large amount of forest land had been cleared, and there had been much upturning of the soil; coincidently the rainfall lessened, and the rivers became far less in volume. At the same time, there was a large increase of population; a great defilement of the ground in the neighborhood of villages and towns, so that in various parts of the island there was a constant drainage down of filth of all kinds (vegetable and animal) into a loose soil of slight depth, resting on impermeable rock, which forms a great deal of the western seaboard. In 1866–67 there occurred an unusually hot season, and again a deficient rainfall. This seems to have brought into active operation the conditions which had been gradually increasing in intensity for some years. The development of the malaria was not so much on the regular marshy ground as on the loose contaminated soil already noticed.

That the fever which in 1866–67 became so general was of malarious type, is proved by a large amount of evidence on the spot from both military and civil practitioners, and from the fact that many soldiers returned to England and had at home relapses of decided paroxysmal fevers. Dr. Maclean also stated that he had seldom seen spleens so enlarged as among the invalids from this fever who arrived at Netley.

But in some respects this fever presented characters different from common paroxysmal fevers. There was no very great mortality among the troops, but it was excessively fatal among the inhabitants of Port Louis and many other towns and villages. It also lasted for many months, and was attended in many cases with symptoms not common in ordinary paroxysmal fevers, viz., with yellowness of the skin and with decided relapses, closely resembling in these respects the common relapsing fever. Mixed up with it also was decided typhoid fever. The question whether the great bulk of the epidemic was a purely paroxysmal or malarious fever, with an independent subordinate outbreak of typhoid fever, or whether it was a composite affection like the "typho-malarial fever" of the American war,[3] or was mixed up with the contagious "Indian jail fever" imported by Coolies, is not a matter very easy to decide. The officers best qualified to judge (Drs. Reid, Small, and Power) looked upon it as a

[1] Letter to the Director-General, February, 1867.

[2] Annual Report on the District Prisons Hospitals (in 1867, Mauritius, 1868). On the Malarial Epidemic Fever of the Mauritius, Army Med. Depart. Report, vol. viii., p. 442.

[3] As described by Woodward, Camp Diseases of the United States Armies, by J. J. Woodward, M.D., Philadelphia, 1863, p. 77.

purely malarious disease, and expressed themselves very strongly on this point.[1]

This much seems certain, that in various parts of the island the loose, porous, shallow soil had been gradually becoming more and more impure with vegetable matters, and in some cases with animal excreta; that there had been a gradual diminution of the subsoil water, and that this reached its maximum in 1866, when the rains failed, and the hot season was prolonged. There coincided, then, an unusual impurity of soil, lowered subsoil water, consequent increased access of air, and heightened temperature. Under these conditions, a usually non-malarious soil gave rise to an epidemic fever, which was characterized (chiefly, at any rate) by the symptoms referred to the action of marsh miasmata, and was curable by quinine. The admissions for paroxysmal fevers alone were, in 1875, 585.5 per 1,000, and in 1869–75 (five years) 722.3 per 1,000 as a mean. In later years the type has been distinctly paroxysmal, the large majority of cases being returned as *ague*. The mean admissions per 1,000 for six years, 1875–80, were 970, with a maximum of 1,557 in 1879.

Per 1,000 *of Strength.*

Years.	Loss of Strength.			Loss of Service.		
	Deaths (all Causes).	Deaths from Disease.	Invaliding.	Admissions.	Mean Daily Sick.	Days in Hospital to each Sick Man.
1817–36	30.5			1,249.0	68.0	20.0
1861–70 (10 years) ..	20.17			1,056.5		
1865–74 (10 years) ..	18.97		44.15	1,419.4	53.58	13.76
1875–80 (6 years) ...	17.89		48.03	2,181.7	70.36	11.65
1880	5.67	2.83	79.32	2,203.9	98.53	16.36

In the Mauritius, as in Jamaica, a "continued fever" is not uncommon; this is now being returned in part as typhoid.[2] It has occasionally been imported. There are fevers vaguely named "bilious remittent," "Bombay fever," "Coolie fever," etc. The last term denotes the communicable fever so common in the jails in the Bengal Presidency. It prevailed in the jails in the Mauritius in 1863 and 1864, among the Hindoos. The "Bombay fever" is probably typhoid. Dysentery and diarrhœa have largely prevailed, but are now becoming less frequent. In this respect Jamaica now contrasts very favorably with the Mauritius; thus, in 1860, there were altogether 213 admissions per 1,000 of dysentery and diarrhœa, and 6.8 deaths per 1,000; in Jamaica, in the same year, there was not a single admission from dysentery, and only 19 from diarrhœa, among 594 men, and no death. Cholera has prevailed five times—first in 1819;

[1] The two latter gentlemen say, op. cit., p. 453—"It was entirely of malarious origin, and in every form, we might say, perfectly curable by administration of quinine in large doses." These observers entirely deny that it had any contagious properties.

[2] Dr. Reid had no doubt of the frequent occurrence of typhoid for many years. He mentioned an interesting fact, viz., that patients with true enteric fever were also affected with the malarious epidemic fever; this latter was, however, easily curable by quinine, but the typhoid fever, which was also present, was quite unaffected.

not afterward till 1854; then again in 1856, 1859, and 1861. (It appears to have been imported in all these cases.) Formerly there was a large mortality from lung diseases; now, as in Jamaica, this entry is much less, not more than half that of former days. The deaths from phthisis per 1,000 of strength were, in 1860, 0.521; in 1861, 1.03; in 1862, 1.94 (but in this year 11 men were invalided for phthisis); and in 1863, 2; in 1875 no death was recorded. Venereal (enthetic) diseases formerly gave about 110 to 130 admissions per 1,000 of strength, but they are now greatly diminished. Ophthalmia prevails moderately; to nothing like the same extent as at the Cape.

In 1873 (the last year of detailed statistics) there were 8 admissions for diarrhœa and none for dysentery in Jamaica; in Mauritius there were 29 for diarrhœa and 16 for dysentery and 2 deaths, out of a strength of 441.

SECTION VII.

CEYLON.[1]

Garrison, 800 to 1,000 white troops; and about 100 gun-lascars (black). Population, 2,758,166 (in 1881), including about 5,000 Europeans. The stations for the white troops are chiefly Galle, Colombo, Kandy, and Trincomalee, with a convalescent station at Newera Ellia (6,200 feet above sea-level). The black troops are more scattered, at Badulla, Pultan, Jaffna, etc.

Geology.—A considerable part of the island is composed of granite, gneiss, and hornblende granite rocks; these have become greatly weathered and decomposed, and form masses of a conglomerate called "cabook," which is clayey like the laterite of India, and is used for building. The soil is derived from the débris of the granite; is said to absorb and retain water eagerly. In some parts, as at Kandy, there is crystalline limestone.

Climate.—This differs, of course, exceedingly at different elevations. At Colombo, sea-level, the climate is warm, equable, and limited. Mean annual temperature about 81°. Mean temperature — April, 82.70°; January, 78.19°; amplitude of the yearly fluctuation = 4.51°. April and May are the hottest months; January and December the coldest. Amount of rain about 74 inches; the greatest amount falls in May with the S.W. monsoon (about 13 to 14 inches); and again in October and November with the N.E. monsoon (about 10 to 12 inches) in each month. Rain, however, falls in every month, the smallest amount being in February and March. The heaviest yearly fall ever noted was 120 inches. The relative humidity is about 80 per cent. of saturation. The S.W. monsoon blows from May to September, and the N.E. monsoon during the remainder of the year, being unsteady and rather diverted from its course (long-shore wind) in February and March. The mean horizontal movement during the year 1872 was 125 miles; in 1870 it was 139 miles, or rather under 6 miles an hour.

At Kandy (72 miles from Colombo, 1,676 feet above sea-level), the mean temperature is less, 3° to 5°; the air is still absolutely humid, though relatively rather dry. At 9.30 A.M. the mean annual dew-point is 70.4°, and at 3.30 P.M. it is 71.54°. This corresponds to 8.11 and 8.42 grains in a cubit foot of air; as the mean temperature at these times is 76.37 and 79.27, the mean annual relative humidity of the air at 9.30 A.M.

[1] For a full account, see Sir E. Tennant's Ceylon.

and 3.30 P.M. is 71 and 63 per cent. of saturation. The heat is oppressive, as Kandy lies in a hollow, as in the bottom of a cup.

At Newera Ellia (48 miles from Kandy, 6,210 feet high) is a large table-land where, since 1828, some Europeans have been stationed; the climate is European, and at times wintry; the thermometer has been as low as 29°, and white frosts may occur in the early morning in the coldest months. The mean annual temperature is about 59°.[1]

In the dry season (January to May) the thermometer's daily range is excessive; the thermometer may stand at 29° at daybreak, and at 8 A.M. reach 62°; at mid-day it will mark 70° to 74°, and then fall to 50° at dark. In one day the range has been from 27° to 74° = 47°. The air is very dry, the difference between the dry and wet bulbs being sometimes 15°. Assuming the dry bulb to mark 70°, this will give a relative humidity of only 38 per cent. of saturation; the barometer stands at about 24.25 inches. Although the diurnal range of temperature is thus so great, it is equable from day to day.

Such a climate, with its bright sun and rarefied air, an almost constant breeze, and an immense evaporating force, seems to give us, at this period, the very beau ideal of a mountain climate.

In the wet season (May or June to November) all these conditions are reversed. The mean thermometer of twenty-four hours is about 59°; and the range is only from 56° at daybreak to 62° at mid-day; during the height of the monsoon, there are about 30 inches of rainfall, and sometimes as much as 70; the air is often almost saturated. The mean of three years (1870–72) gives no less than 94½ inches.[2]

Two more striking climatic differences than between January and June can hardly be conceived, yet it is said Newera Ellia is equally healthy in the wet as in the dry season; the human frame seems to accommodate itself to these great vicissitudes without difficulty. The most unhealthy times are at the changes of the monsoons.

Although there is some moist and even marshy ground near the station, ague is not common, though it is seen; the temperature is too low in the dry season, and the fall of rain too great in the wet. Typhoid fever is seen, and may be combined with periodic fever.[3] It is said that dyspepsia, hepatic affections, and nervous affections are much benefited; phthisis is so to some extent, but, it would appear, scarcely so much as European experience would have led us to expect; rheumatism does not do well, nor, it is said, chronic dysentery; but it would be very desirable to test this point, as well as that of the influence on phthisis, carefully. The so-called "hill diarrhœa" of India prevailed in 1865, though before this it is unknown. Dysentery has sometimes prevailed, and is caused in some cases by bad water (Massy).

The soil of Newera Ellia is chiefly decomposed gneiss; it is described by Dr. Massy as being as hygroscopic as a sponge; the contents of cesspools easily traverse it, and the removal of excreta demands great care.

The neighboring Horton Hills are said to be even better than Newera Ellia itself. Probably, in the whole of Hindustan, a better sanitary station does not exist. It is inferior, if it be inferior, only to the Neilgherries, and one or two of the best Himalayan stations.

[1] Many of these facts are from an excellent Report by Assistant-Surgeon R. A. Allan, as well as from Sir E. Tennant's book.

[2] Since 1873 all meteorological information about Ceylon has been dropped out of the Army Medical Reports.

[3] Massy, in Army Med. Reports, vol. viii., p. 499.

Sickness and Mortality[1] *of Europeans per* 1,000 *of Strength.*

Years.	Deaths.	Admissions.	Mean Daily Sick.	Duration of Sickness.
1860–69 (10 years).....	23.75	1,424.9	66.52	16.6 days.
1869–74 (6 years).....	17.72	1,112.6		
1875–80 (6 years).....	16.45	976.4	52.86	20.00 "

Influence of Age on Mortality.

	Under 20 years.	20 and under 25.	25 and under 30.	30 and under 35.	35 and under 40.	40 and over.
1864–73	5.79	15.89	28.81	26.50	50.25	173.91

Among the black troops, now reduced to about 100 altogether, in Ceylon (1860–69) the admissions averaged 1,011, and the deaths 15.17, per 1,000 of strength. In 1870 the total mortality was 9.44 (and in 1880, 11.63) per 1,000. The chief causes of admissions were paroxysmal fevers, and of deaths, cholera, dysentery, and paroxysmal fevers. "Continued fever" also figures among the returns, but was less common in the later years. The average number constantly sick was about 32, and the duration of the cases 10 or 11 days.

In Ceylon, therefore, the black troops were healthier than the white, contrasting in this remarkably with the West Indies.

In conclusion, it may be said that much sanitary work still remains to be done in Ceylon before the state of the white troops can be considered satisfactory.

SECTION VIII.

INDIA.

About 50,000 Europeans are now (1880) quartered in India, and there is in addition a large native army. In this place the Europeans will be chiefly referred to, as it would require a large work to consider properly the health of the native troops.[2]

The 50,000 Europeans are thus distributed:—About 31,000 are serving in the Bengal Presidency, which includes Bengal proper, the Northwest Provinces, the Punjab, and the Trans-Indus stations. About 10,000 are

[1] In 1876 the death-rate was only 7.43, but this was exceptional; in 1880 it was 25, the great excess being due to dysentery in the Colombo garrison.

[2] The general principles of hygiene are of course to be applied in the case of the natives of Hindustan, and so far there is nothing unusual. In the chapter on FOOD, some of the articles of diet have been referred to; the question of water and air is the same for all nations, and other hygienic rules of clothing or exercise can be easily applied to them. But their health is much influenced by their customs, which are in many races peculiar. The only proper way of treating such a subject would be by a work on the hygiene of India generally, including the native army as a branch of the community.

serving in the Madras Presidency, which also garrisons some parts of the coast of Burmah, and sends detachments of native troops to the Straits of Malacca. About 9,000 are serving in the Bombay Presidency.[1] The troops consist of all arms.

These men are serving in a country which includes nearly 28° of lat. and 33° of long., and in which the British possessions amount to 1,470,207 square miles, and the population to 253,000,000. Stretching from within 8° of the equator to 13° beyond the line of the tropics, and embracing countries of every elevation, the climate of Hindustan presents almost every variety; and the troops serving in it, and moving from place to place, are in turn exposed to remarkable differences of temperature, degrees of atmospheric humidity, pressure of air, and kind and force of wind, etc.

Watered by great rivers which have brought down from the high lands vast deposits in the course of ages, a considerable portion of the surface of the extensive plains is formed by alluvial deposit, which, under the heat of the sun, renders vast districts more or less malarious; and there are certain parts of the country where the development of malaria is probably as intense as in any part of the world. A population, in some places thickly clustered, in others greatly scattered, formed of many races and speaking many tongues, and with remarkably diverse customs, inhabits the country, and indirectly affects very greatly the health of the Europeans.

Cantoned over this country, the soldiers are also subjected to the special influences of their barrack life, and to the peculiar habits which tropical service produces.

We can divide the causes which act on the European force into four subsections—

1. The country and climate.
2. The diseases of the natives.
3. The special hygienic conditions under which the soldier is placed.
4. The service and the individual habits of the soldier.

Sub-Section I.—The Country and Climate.

The geological structure and the meteorological conditions are, of course, extremely various, and it is impossible to do more than glance at a few of the chief points.

1. *Soil.*[2]—There is almost every variety of geological structure. In the northwest, the vast chain of the Himalayas is composed of high peaks of granite and gneiss; while lower down is gneiss and slate, and then sandstone and diluvial detritus. Stretching from Cape Comorin almost to Guzerat, come the great Western Ghauts, formed chiefly of granite, with volcanic rocks around; and then, stretching from these, come the Vindhya and Satpoora Mountains, which are chiefly volcanic, and enclose the two great basins of the Taptee and Nerbudda rivers. Joining on to the Vindhya, come the Aravalli Hills, stretching toward Delhi, and having at their highest point Mount Aboo, which is probably destined to become the great health resort of that part of India.

[1] For brevity, it is customary to speak of serving in Bengal, Bombay, or Madras, when speaking of the Presidency, so that these names are sometimes applied to the cities, sometimes to the presidencies; but a little care will always distinguish which is meant.

[2] See Carter's Summary of the Geology of India, in the Journal of the Bombay Asiatic Society's Transactions, 1853.

On the east side, the lower chain of the Eastern Ghauts slopes into the table-land of the Deccan; and at the junction of the Eastern and Western Ghauts come the Neilgherry Hills, from 8,000 to 9,000 feet above sea-level, and formed of granite, syenite, hornblende, and gneiss. But to enumerate all the Indian mountains would be impossible.

Speaking in very general terms, the soil of many of the plains may be classed under four great headings.

(*a*) Alluvial soil, brought down by the great rivers Ganges, Indus, Brahmapootra, rivers of Nerbudda, Guzerat, etc. It is supposed that about one-third of all Hindustan is composed of this alluvium, which is chiefly siliceous, with some alumina and iron. At points it is very stiff with clay—as in some parts of the Punjab, in Scinde, and in some portion of Lower Bengal. Underneath the alluvial soil lies, in many places, the so-called clayey laterite. Many of the stations in Bengal are placed on alluvial soil.

This alluvial soil, especially when, not far from the surface, clayey laterite is found, is often malarious; sometimes it is moist only a foot or two from the surface; and, if not covered by vegetation, is extremely hot.

As a rule, troops should not be located on it. Whatever be done to the spot itself—and much good may be done by efficient draining—the influences of the surrounding country cannot be obviated. Europeans can never be entirely free from the influences of malaria. There is but one perfect remedy; to lessen the force in the plains to the smallest number consistent with military conditions, and to place the rest of the men on the higher lands.

Somewhat different from the alluvial is the soil of certain districts, such as the vast Runn of Cutch, which have been the beds of inland seas, and now form immense level marshy tracks, which are extremely malarious. The Runn of Cutch contains 7,000 square miles of such country.

(*b*) The so-called "regur," or "cotton soil," formed by disintegrated basalt and trap, stretches down from Bundelcund nearly to the south of the peninsula, and spreads over the table-land of Mysore, and is common in the Deccan. It is often, but not always, dark in color. It contains little vegetable organic matter (1.5 to 2.5 per cent.), and is chiefly made up of sand (70 to 80 per cent.), carbonate of lime (10 to 20 per cent.), and a little alumina. It is very absorbent of water, and is generally thought unhealthy. It is not so malarious as the alluvium, but attacks of cholera have been supposed to be particularly frequent over this soil.

(*c*) Red soil from disintegration of granite. This is sometimes loamy, at other times clayey, especially where felspar is abundant. The clay is often very stiff.

(*d*) Calcareous and other soils scattered over the surface, or lying beneath the alluvium or cotton soil. There are, in many parts of India, large masses of calcareous (carbonate of lime) conglomerate, which is called kunkur. It is much used in Bengal for pavements, footpaths, and roads generally.

In Behar, and some other places, the soil contains large quantities of nitre, and many of the sand plains are largely impregnated with salts.

2. *Temperature.*—There is an immense variety of temperature. Toward the south, and on the sea-coast, the climate is often equable and uniform. The amplitudes of the annual and diurnal fluctuations are small, and in some places, especially those which lie somewhat out of the force of the southwest monsoon, the climate is perhaps the most equable in the world.

At some stations on the southern coast, the temperature of the sun's

zenith is lower than at the declination, in consequence of the occurrence of clouds and rain, brought up by the southwest monsoon.

In the interior, on the plateaux of low elevation, the temperature is greater, and the yearly and diurnal fluctuations are more marked. On the hill stations (6,000 to 8,000 feet above sea-level), the mean temperature is much less; the fluctuations are sometimes great, sometimes inconsiderable.

The influence of winds is very great on the temperature; the sea winds lowering it, hot land winds raising it greatly.

The temperature in the sun's rays ranges as high as 166° or 170°, but the mean sun rays' temperature is, with great differences in different places, between 130° and 160° at the hottest time of the year.

The air temperature of a few of the principal stations is subjoined, merely to give an idea of the amount of heat in different parts of the country.[1] Those of the hill stations are given under the proper headings.

Mean Temperature and Height, above Sea-level, of some of the larger Stations.

Months.	Calcutta, Fort William, 8 feet above sea-level.	Punjab, generally 800 to 900 ft. above sea-level.	Peshawur, 1,056 feet above sea-level.	Madras, Fort St. George, at sea-level.	Bangalore 3,000 ft. above sea-level, 1 year only.	Bombay, at sea-level.	Poonah 1,809 feet above sea-level.	Belgaum, 2,300 feet above sea-level.
	°	°	°	°	°	°	°	°
Mean of year	82	73	74	82	76	80	78	74
January	70	54	52	76	69	74	72	72
February	75	60	55	78	73	76	75	75
March	83	68	65	80	79	80	79	78
April	88	77	75	84	79	83	83	81
May	89	86	88	87	82	86	85	78
June	87	89	91	88	77	83	81	75
July	85	87	91	85	77	81	77	73
August	85	86	88	85	75	81	76	72
September	85	83	84	84	76	80	77	74
October	84	76	73	82	75	82	79	74
November	78	61	64	79	73	79	76	72
December	72	55	56	76	71	76	73	70
Amplitude of yearly fluctuation (difference between hottest and coldest months)	19	35	39	12	13	12	13	11

The increase and the amplitude of the yearly fluctuation is thus seen as we pass to the north, and ascend above sea-level.

In several places there are great undulations of temperature from hot land winds, or from sea or shore breezes, or from mountain currents, which give to the place local peculiarities of temperature.

To get the same mean annual temperature as in England, it would be necessary that 9,500 feet be ascended in places south of lat. 20°; between

[1] These are taken from Mr. Glaisher's very excellent report in the Indian Sanitary Commission, which must be consulted for fuller details. Very full meteorological returns are now being given in the Reports of the Sanitary Commissioners for the three presidencies, and these will ultimately supersede Mr. Glaisher's tables.

lat. 20° and 26°, 9,000 feet; between lat. 26° and 30°, 8,700 feet; and north of lat. 30°, 8,500 feet.

The mean monthly temperatures would, however, at such elevations, differ somewhat from those of England. Speaking generally, an elevation of 5,000 to 6,000 feet will give over the whole of India a mean annual temperature about 10° higher than that of England, and with a rather smaller range.

Mr. Glaisher has calculated that in the cold months the decrease of temperature is 1.05° for each 300 feet of ascent, but increases from March to August to 4.5°, and then gradually declines. These results are not accordant with the results of balloon ascents in this climate.

Humidity.—The humidity of different parts of India varies extremely; there are climates of extreme humidity—either flat, hot plains, like Lower Scinde, where, without rain, the hot air is frequently almost saturated, and may contain 10 or 11 grains of vapor in a cubic foot; or mountain ranges like Dodabetta, in Madras, 8,640 feet above sea-level, where during the rainy season the air is also almost saturated; a copious rain, at certain times of the year, may make the air excessively moist, as on the Malabar coast, the coast of Tenasserim, or on the Khasyah Hills, where the southwest monsoon parts with its vapors in enormous quantities.

On the other hand, on the elevated table-land of the interior, and on the hot plains of Northwest India, during the dry season, or in the places exposed to the land winds at any part, the air is excessively dry. In the Deccan the annual average of the relative humidity is only 55 per cent. of saturation (Sykes). Mr. Glaisher has given the humidity of many places. A few stations are here given :—

Mean Humidity per cent.

	Fort William.	Madras, Fort St. George.	Bombay.	Benares.	Meerut.	Peshawur.	Bellary.	Secunderabad.	Poonah.	Kurrachee.	Belgaum.
Mean maximum	81	79	85	94	84	73	76	84	79	80	84
" minimum.....	59	61	67	44	54	41	40	40	42	48	43
Yearly mean	68	72	73	69	67	55	56	54	53	62	64

The mean relative humidity at Greenwich is 82, varying from 89 in December and January to 76 in July. Calcutta, therefore, with a mean yearly humidity of 68 per cent. of saturation, is, as far as relative humidity (*i.e.*, evaporating power) goes, less moist than England, and the evaporating power is also increased by the higher temperature.

Rain.—The amount of rain and the period of fall vary exceedingly in the different places. It is chiefly regulated by the monsoons.

When the southwest monsoon, loaded with vapor, first strikes on high land, as on the Western Ghauts, on the Malabar coast, or on the mountains of Tenasserim, and especially on the mountains of the Khasyah Hills, at some points of which it meets with a still colder air, a deluge of rain falls; as, for example, at Cannanore (Malabar), 121 inches; Mahableshwur, 253 inches; Moulmein (Tenasserim), 180 inches; Cherrapoonjee (Khasyah Hills), 600 inches. On the other hand, even in places near the sea, if there is no high land, and the temperature is high, scarcely any rain falls;

as in Aden, on the south coast of Arabia, or at Kota, in Scinde, where the amount is only 1.8 annually, or Kurrachee, where the yearly average is only 4.6 inches. Or in inland districts, the southwest monsoon, having lost most of its water as it passed over the hills, may be comparatively dry, as at Nusserabad, where only 15.8 inches fall per annum, or Peshawur, where there are 13.7 inches annually.

The yearly amount of rain in some of the principal stations is—

	Average.
Calcutta	56.8
Madras	50
Bombay	72.7
Bengal Presidency—	
Dinapore	31.1
Berhampore	49.8
Benares	37.4
Ghazeepore	41.4
Azimghur	40
Agra	27.9
Delhi	25.1
Meerut	18
Punjab	56.6
Madras Presidency—	
Bellary	21.7
Bangalore	35
Trinchinopoly	30.6
Secunderabad	34.6
Bombay Presidency—	
Belgaum	51.5
Poonah	27.6
Neemuch	34.1
Kamptee	21.8

Winds.—The general winds of India are the northeast monsoon, which is, in fact, the great northeast trade-wind, and the southwest monsoon, a wind caused by the aspiration of the hot earth of the continent of Asia, when the sun is at its northern declination. During part of the year (May to August) the southwest monsoon forces back the trade-wind or throws it up, for at great altitudes the northeast monsoon blows through the whole year, and the southwest monsoon is below it. But, in addition, there are an immense number of local winds, which are caused by the effect of hills on the monsoons, or are cold currents from hills, or sea breezes, or shore winds caused by the contact of sea breezes and other winds, or by the first feeble action of the southwest monsoon before it has completely driven back the northeast trade. The southwest monsoon is in most of its course loaded with vapor; the northeast is, on the contrary, a colder and drier wind, except when at certain times of the year, in passing over the Indian Ocean, it takes up some water, and reaches the Coromandel coast and Ceylon as a moist and rain-carrying wind.

The hot land-winds are caused by both the southwest monsoon, after it has parted with its moisture and got warmed by the hot central plains, and the northeast monsoon; the temperature is very great, and the relative humidity very small, the difference between the dry and the wet bulb being sometimes 15° to 25° Fahr.

Pressure of the Air.—On this point little need be said. The barometer is very steady at most sea-coast stations, with regular diurnal oscillations, chiefly caused by alteration in humidity. An elevation of 5,000 feet lowers the barometer to nearly 26 inches.

Electricity.—On this point few, if any, experiments have been made; the air is extremely charged with electricity, especially in the dry season, and the dust-storms are attended with marked disturbance of the electrometer.[1]

[1] See Baddeley's Whirlwinds and Dust Storms of India (1860) for a very good account of these singular storms.

Effects of Climate.—The estimation of the effects of such various climates is a task of great difficulty. Long-continued high temperature, alternations of great atmospheric dryness and moisture, rapidly moving and perhaps dry and hot air, are common conditions at many stations; at others, great heat during part of the year is followed by weather so cold that even in England it would be thought keen. When to these influences the development of malaria is added, enough has been said to show that, *a priori*, we can feel certain that the natives of temperate climates will not support such a climate without influence on health, and the selection of healthy spots for troops is a matter of the greatest moment as affects both health and comfort. This much being said, it must at the same time be asserted that, malaria excepted, the influences of climate are not the chief causes of sickness.

The location of troops should be governed by two or three conditions—1. Military necessities; 2. Convenience; 3. Conditions of health. The second of these conditions is, however, a mere question of administration; every place can be made convenient in these days of railway and easy locomotion. Military necessity and health are the only real considerations which should guide our choice. The vital military points must be held with the necessary forces, and then the whole of the remaining troops can be located on the most healthy spots.

These spots cannot be in the plains. Let any one look at a geological map of India, and see the vast tract of alluvial soil which stretches from the loose soil of Calcutta, formed by the deposit of a tidal estuary, up past Cawnpore, Delhi, to the vast plains of the Punjab, Scinde, and Beloochistan. The whole of that space is more or less malarious, and will continue to be so until, in the course of centuries, it is brought into complete tillage, drained, and cultivated. Moreover, heat alone without malaria tells upon the European frame, lessens the amount of respiration and circulation, and lowers digestive power.

In looking for healthy spots, where temperature is less tropical, and malarious exhalations less abundant, there are only two classes of localities which can be chosen—sea-side places and highlands.

Sea-side Places.—The advantages of a locality of this kind are the reduction in temperature caused by the expanse of water, the absence of excessive dryness of the air, and the frequent occurrence of breezes from the sea. All these advantages may be counteracted by the other features of the place; by a damp alluvial soil, bad water, etc.

It does not appear that many eligible places have yet been found, and as a substitute in Bengal, the Europeans from Calcutta sometimes live on board a steamer anchored off the Sandheads, thus literally carrying out a suggestion of Lind in the West Indies a century ago.

In the Bay of Bengal, Waltair, in the northern division of Madras, is one of the best.[1] Cape Calimere (28 miles south of Nagapatam) also appears to have many advantages (Macpherson). On the opposite coast, Cape Negrais, on the Burmese coast, was pointed out as long ago as 1825, by Sir Ranald Martin, as a good marine sanitarium, and Amherst in Tenasserim, and some of the islands down the coast toward Mergui, are beautiful spots for such a purpose, being, however, unfortunately, at a great distance from the large military stations, and not being well supplied with food.

On the Bombay side, at Sedashagur or Beitkul Bay, between Mangalore

[1] Evidence of Dr. Maclean in India Report, p. 139.

and Goa, a spur of the Western Ghauts projects into the sea for upward of a mile, and forms an admirable sea-coast sanitarium (Macpherson).

All these sea-coast stations seem adapted for organic visceral affections and dysentery, but they are not so well calculated for permanent stations for healthy men. Probably they are rather sanitaria than stations.

Highlands.—The location of troops on the hills or on elevated table-lands has long been considered by the best army medical officers as the most important sanitary measure which can be adopted. Not only does such a location improve greatly the vigor of the men, who on the hill stations preserve the healthy, ruddy hue of the European, but it prevents many diseases. If properly selected, the vast class of malarious diseases disappears ; liver diseases are less common, and bowel complaints, in some stations at any rate, are neither so frequent nor so violent. Digestion and blood nutrition are greatly improved. Moreover, a proper degree of exercise can be taken, and the best personal hygienic rules easily observed.

Indian surgeons appear, however, to think the hill stations not adapted for cardiac and respiratory complaints ; it is possible that this objection is theoretical. The latest European experience is to the effect that phthisis is singularly benefited by even moderate, still more perhaps by great elevation ; that anæmia and faulty blood nutrition are cured by high positions with great rapidity, and that if the elevation be not too great (perhaps not over 3,000 feet) even chronic heart diseases are improved. In some of the hill stations of India bowel complaints were formerly so frequent as to give rise to the term "hill diarrhœa." The elevation was credited with an effect which it never produced, for, not to speak of other parts of the world, there are stations in India itself (Darjeeling, for example) as high as any other, where the so-called hill diarrhœa was unknown. At Newera Ellia, in Ceylon, too, if the simple condition of mountain elevation could have produced diarrhœa, it would have been present. The cause of the hill diarrhœa was certainly, in many stations, unwholesome drinking-water ; whether or not this was the case in all is uncertain. Some of the hill stations are said not to be adapted for rheumatic cases ; in other instances (as at Subathoo) rheumatism is much benefited. From reading the reports from these stations, it is more probable that damp barracks, and not the station, have been in some cases the cause of the rheumatism.

But it must be noticed that the evidence given before the Indian Sanitary Commission shows, on all or almost all hill stations, a most lamentable want of the commonest sanitary appliances. At great expense men are sent up to the hills, where everything is, or was, left undone which could make that expense profitable. It appeared to be thought sufficient to ascend 6,000 feet to abandon all the most obvious sanitary rules, without which no place can be healthy.

Admitting, as a point now amply proved, that stations of elevation are the proper localities for all troops not detained in the plains by imperative military reasons, the following questions are still not completely answered :—

1. What amount of elevation is the best? We have seen that to reduce the temperature to the English mean, 5,000 to 6,000 feet must on an average be ascended. But then such an elevation brings with it certain inconveniences, viz., in some stations much rain and even fog at certain times of the year, and cold winds. However unpleasant this may be, it yet seems clear, from the experience of Newera Ellia, in Ceylon, that damp and cold are not hurtful. But it must also be said that, with a proper selection, dry localities can be found at this elevation.

From 3,000 to 4,000 feet have been recommended, especially to avoid the conditions just mentioned. Whether places of this height are equal in salubrity to the colder and higher points is uncertain.

Even at 6,000 feet there may be marsh land, though it is not very malarious. Malarious fever has been known during the rains at Kussowlie (6,400 feet), and Subathoo (4,000), and other Himalayan stations. Malaria may, however, drift up valleys to a great height,[1] but, apart from this, it seems likely that 5,000 feet, and probably 4,000, will perfectly secure from malaria. Probably, indeed, a less height will be found effectual.

At no point do hot land-winds occur, or at any rate endure, at above 4,000 feet. On the whole, it would appear probable that the best localities are above 5,000 feet, but below 7,000.

2. What stations are the best—the tops of solitary hills, spurs of high mountains, or elevated table-lands?

Ranald Martin has called especial attention to the solitary hills, rising as they do sometimes from an almost level plain to 2,000 and 3,000 feet. Such mountain islands seem especially adapted for troops if there is sufficient space at the top. They are free from ravines conducting cold air from higher land, and are often less rainy than the spurs of loftier hills.

The spurs of the Himalayas, however, present many eligible spots, and so do some table-lands. And perhaps, on the whole, if the elevation is sufficient, it is not a matter of much importance which of these formations is chosen; other circumstances, viz., purity of water, space, ease of access, and supplies, etc., will generally decide.

In choosing hill stations, the points discussed in the chapter on Soils should be carefully considered, and it is always desirable to have a trial for a year or two before the station is permanently fixed.

In all the presidencies of India elevated spots where troops can be cantoned exist in abundance.[2] The following table, copied from Dr. Macpherson's work, gives some of the principal hill stations. Fresh stations are, however, being constantly discovered, and it seems now certain that there is scarcely any important strategical point without an elevated site near it.

Near Nynee Tal, in Kumaon, are Almorah (5,500 feet) and Hawalbagh (4,000 feet), both well spoken of. Kunawar (5,000 or 6,000 feet), in the valley of the Sutlej, has a delicious climate; and Chini (about 100 miles from Simla) is a most desirable spot.

Passing down from the northwest toward Calcutta, Dr. M'Clellan found elevated land within 100 miles of Allahabad; and in the south there are the Travancore Mountains, with numerous good sites.

If, then, the mass of the troops are cantoned on elevated places, the disadvantages of climate are almost removed. The Indian Sanitary Commissioners recommended that one-third of the force shall be in the hills, and

[1] It has drifted up even to the summits of the Neilgherries, 7,000 or 8,000 feet.—Indian Sanitary Report, Mr. Elliott's Evidence, vol. i., p. 250.

[2] See the evidence in the Indian Sanitary Report (vol. i.) of Sir R. Martin, Mr. Elliott, Dr. Maclean, Dr. Alexander Grant, Mr. Montgomery Martin, and others. Also most instructive reports by Mr. Macpherson, Indian Report, vol. ii., p. 622; and by Dr. Alexander Grant, Indian Annals. On the location of troops reference may also be made to the late Surgeon-General Dr. Beatson's very decided opinion on the necessity of placing on the hills all the men who can be spared from the military posts in the plains. No more valuable opinion could be given on such a point than that of an officer who had the largest possible experience, and the best opportunities of forming a correct judgment. (See his Report in the Army Med. Report, vol. viii., p. 347.) Sir William Muir also urged this point, and the result is that gradually more and more troops are being located on the hills.

	Names of Hill Stations.		Mean Temperature outside in Shade.												Ascertained greatest Elevation.	Average Fall of Rain in Inches.
			January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.		
Bengal Presidency.	Darjeeling,		40	41	51	55	61	62	63	64	63	55	50	44	8000	132
	Simla,		40	44	53	61	66	80	75	78	70	67	52	46	8000	70
	Landour,		35	40	51	...	...	...	...	68	64	49	46	46	7300	...
	Murree,		...	...	...	...	...	69	68	66	62	62	...	...	6786	...
	Kussowlie,		42	47	58	64	77	73	70	70	72	66	...	...	6400	70
	Nynee Tal,		42	46	56	61	69	69	67	69	65	61	50	47	6200	83
	Dugshai,		42	47	57	64	69	71	72	68	66	62	54	53	6000	70
	Subathoo,		...	...	...	77	81	84	79	77	...	...	...	...	4000	70
Madras Presidency.	Ootacamund,	Neilgherry range,	54	56	60	61	61	57	63	63	62	56	54	53	7361	60
	Kotagherry,	Neilgherry range,	59	60	61	63	63	64	65	65	64	62	60	59	6100	55
	Wellington,	Neilgherry range,	59	61	67	68	68	64	70	70	70	63	61	60	5840	50
	Coonoor,	Neilgherry range,	60	62	68	68	68	65	70	70	70	65	62	62	5161	50
	Pulneys,		51	53	60	61	...	...	...	...	...	...	...	...	7000	...
	Mercara,		53	56	61	64	44	66	65	65	64	65	63	56	4500	100
	Annamullays,		...	...	...	...	...	...	...	...	66	56	...	...	6600	...
	Shevaroys.		65	65	68	71	71	68	68	68	67	66	66	65	5260	40
	Ramandroog,		70	76	80	80	75	73	71	70	70	71	71	67	3400	46
	Checuldah,		60	60	70	83	83	71	...	...	...	...	71	71	3600	...
	Sindwarrah,		An average of 8° lower than the station of Kamptee.													
	Muthoor,		Do. 11° do. do.													
Bombay Presidency.	Mahableshwur,		63	65	72	74	72	67	63	64	64	66	64	63	4700	240
	Poorandhur,		67	73	77	78	73	70	67	65	67	71	69	64	4200	73
	Mount Aboo,		61	61	79	77	77	77	69	69	69	69	69	71	4015	79

that enfeebled men and recruits especially shall be sent there. But it is to be hoped that not only one-third, but a large majority of the troops will eventually be placed there.

Sub-Section II.—Diseases of the Natives.

It is impossible that Europeans can be perfectly isolated from the nations among whom they serve; they have suffered from the pestilential diseases of the Hindus, but still it is wonderful that they have not suffered more. Cholera is the chief disease, which, arising in the native population, scourges their conquerors. Some fevers also, relapsing fever, perhaps a "febris icterodes," or bilious remittent, which has attacked Europeans, have had their origin, or at any rate their conditions of spread, in the dense populations of native cities. Happily, the Black Death (the Maha murree, or Pali plague) has never yet spread to the troops, and has indeed been confined within narrow limits. Still these pestilences among the native population are an ever-present menace to Europeans, and, as in the case of cholera, may pass to them at any time. Cholera, certainly, will never be extirpated until attacked in its strongholds, among the miserable dwellings which make so large a part of every Oriental city. In 1867 there were some cases among the troops of the contagious fever which has caused so much mortality in many of the Bengal jails. The exact influence on Europeans of the customs and modes of life of the natives of India has not been made an object of special study, but it cannot be inconsiderable. In many places the Europeans and the natives are in close neighborhood, and the air at all times, and often the water, must be influenced by the social life of the native races. The proximity to large cities or bazaars is indeed often alluded to by army officers as influencing the health of their men; it would be very interesting to know the precise effect. The sanitary condition of almost all the large native towns, and the sanitary habits of the country people, are as bad as can be. Bad water, fetid air, want of sewage removal, and personal habits of uncleanliness, abound everywhere. The Report of the India Sanitary Commission, and the activity of the Indian officials in the Sanitary Departments, are now beginning a series of changes in this respect, which will probably change, *in toto*, the medical history of India.

Sub-Section III.—Special Hygienic Conditions.

The special hygienic conditions (apart from locality) under which the soldier serves in India have been the main causes of excess of disease. This subject has received a searching inquiry from the Sanitary Commissioners.[1] They declare—and after reading the Station Reports and the evidence given before them, no one will doubt the assertion—that while malaria, extremes of temperature, moisture, and variability of temperature cause a certain amount of sickness, "there are other causes of a very active kind connected with stations, barracks, hospitals, and the habits of the men, of the same nature as those which are known in colder climates to occasion attacks of those very diseases from which the Indian army suffer so severely."

And the Commissioners enumerate a list of causes connected with un-

[1] Report of the Commissioners on the Sanitary State of the Army in India, 1863. Report, p. 79, published in 1864 in small bulk.

healthy stations, bad barracks, overcrowding, impure air and water, bad drainage, imperfect ablution, inferior rations and cooking, etc.

In fact, no doubt can exist in the minds of all who have studied the subject that these form the most potent class of causes which affect health.

Sub-Section IV.—Habits and Customs of the Troops.

The habits of the men and the customs of service were, however, also great causes of diseases, and are still so to some extent.

The men were, as a rule, intemperate, great smokers, and indisposed for exertion. It has, indeed, been pointed out with truth, that in proportion to their amount of exercise the men were much overfed, and some diseases of the liver appear to result directly from this simple condition.

The want of exercise is not always the fault of the men. The early morning hours, and often the evening, are occupied with parades; in the period between, the men used to be confined to barracks, and are still sometimes so. Here, listless, unoccupied, and devoured with ennui, they passed the weary day, lying down perhaps for hours daily, or lounging on chairs smoking.

This forced confinement to barracks is indeed an evil often greater than that it is intended to remove. To prevent men from passing out into the sun they are compelled to remain in a hot, often ill-ventilated room, worse for health than the intensest rays of the sun,[1] that scape-goat of almost every fault and vice of Indian life.

All these causes have been summed up by Miss Nightingale in some of those telling sentences which have done more than anything else to force attention to these vital questions.[2]

Of late years a great change has taken place in the habits of the men—more open-air exercises of all kinds; and in the cooler stations athletic

[1] The late Dr. Parkes writes—"I shall never forget the sufferings of the men in the old barracks at Madras. We arrived there from Moulmein, where the men had never been confined to barracks, and where, during two hot seasons, no injury had resulted from allowing them to go out when they liked. On arrival at Madras, in accordance with invariable custom, the men were confined to barracks. They lay all day on their beds, reeking with perspiration; the place was so small and ventilation so bad, that the heat was perfectly intolerable in the barracks, though the sun's rays were quite bearable. The sufferings were extreme. When the afternoon came, more injury had been done by the hot and impure air than exposure to the sun's rays could have caused.

"At Moulmein, in Tenasserim, at one time, two European regiments served together. The barracks of each were perfectly healthy; the food and duties were the same; yet one showed a sick-list and mortality always much greater than the other. Serving in the station shortly afterward, I was so struck by this difference that I went over all the returns and reports in the staff-surgeon's office to make out the cause; the only difference I could detect was, that in the sickly regiment the men were confined to barracks, in the other they were allowed to go about as they pleased. Many years afterward, I met with a medical officer who had served in the sickly regiment, and learned from him that he had always considered the confinement to barracks, and the want of exercise, and the impure air breathed by that system almost night and day, to have been the cause of a disparity so striking. No one would recommend imprudent exposure to the sun; men may be trusted to avoid its intensest rays; but to reduce men to enforced idleness for many hours, and to confine them in the small space of a barrack-room, is not the way of meeting the evil." (On this point see also Dr. Clark's observations on want of exercise as compared with exposure to the sun on the West Coast of Africa.) On this point, as in many others, the statements of Dr. Kenneth Mackinnon are deserving of great attention. His remarks on the desirability of exercise, even in the trying climate of Tirhoot, in Bengal, are very striking. (A Treatise on Public Health, by Kenneth Mackinnon, M.D., Cawnpore, 1848, pp. 27 and 145.) He strongly recommended open sheds and gymnasia, and these are now being adopted.

[2] How People may Live and not Die in India, by Florence Nightingale, 1863.

sports and cricket have been encouraged; in some of the hill stations the troops have been employed in making roads and public works, and the practice of trades has been promoted. Were the troops chiefly on the hills, as much exercise as at home would be possible, and the men would preserve their European vigor and appearance. But even in the plains exercise is necessary, and if it be taken at the proper times (*i.e.*, with avoidance of the three or four hottest hours), and with proper precautions, such as keeping the head and spine well covered and cool, putting on after profuse sweating dry and thin mixed cotton and woollen underclothes, and protecting the loins and abdomen with a silk or flannel sash, and avoiding stimulants before and during the exercise, all men would be benefited even by very great exercise.

The pale, feeble appearance of persons who keep much in the darkened houses is really owing more to the absence of light and to the unhealthy and sedentary life than to the effect of the climate.

The subject of clothing has been already referred to. In Algeria, as in India, much good has been ascribed to the use of very large flannel belts, which the French suspend from the shoulders, a plan better adapted for comfort than the so-called cholera belts of India.

With regard especially to diet, two points must be considered:—

1. What amount of food should be taken? In India, as in all parts of the world, food should be taken in proportion to the mechanical work done by the body, and to the equivalent of mechanical energy, viz., animal heat.

High temperature, as lessening the loss of the body heat, must, *pro tanto*, lessen the need of food to supply the temperature; and it has been supposed that the diet of men in cold countries (Arctic regions) and in hot, contrasted remarkably in respect of the amount of carboniferous food taken by each. But although it is certain that large quantities of meat and fat are taken by men living in or arriving in cold countries, it is now known that the natives of some of the hottest parts of the world take immense quantities of both fats and starches. In fact, both these substances are taken to supply mechanical energy directly, as well as animal heat. It is not, in fact, yet known what amount of lessening of food, or what kind of lessening, the increased heat of the tropics demands, or whether any is demanded, for exact experiments are wanting. Our best guide at present for the quantity of food to be taken in the tropics, is to apportion it to the amount of mechanical work done, as in temperate climates. In India, as elsewhere, it must be in balance with exercise. The points then to be considered are the amounts of daily food and of daily exercise, and by means of the tables formerly given, and by knowing the habits of the men, little difficulty will be found in determining the proper ration quantity of food with accuracy.

In considering the amount of food, it must be remembered that the soldier almost always buys additional food, and often eats much more than his ration. Some years ago Dr. Macnamara found the troops in Bengal taking no less than 76 ounces of food (*i.e.*, water-containing food), while the regulation ration was only 52 ounces, so that these men were largely over-feeding. And Dr. Dempster[1] states that the majority of the recruits from Scotland and England eat in the hot weather in India much more animal food than in the coldest seasons in their native countries.[2]

[1] Indian Sanitary Report—Evidence.

[2] Colonel Sykes long ago directed particular attention to this point, stating with perfect truth that the soldier in India is over-stimulated by food and drink, and understimulated by bodily and mental exercise.

It would therefore seem that illness may arise in India from excess of food, but it is not the regulation ration which produces it, but the additional purchased food, which is often of bad quality, or the extreme idleness of the men, in which case even the regulation ration is too much. The only remedy is instruction of the men in what is good for them, and no men are so stupid as not to perceive what is best for their own comfort and happiness when it is once pointed out to them.

In addition, the soldier in India had till very lately the spirit ration (now lessened to one-half), which has the effect of lessening the power of appropriation of food, though not always the appetite, and thus indirectly may cause over-feeding.

2. Admitting (till better observations are made) that men in the tropics, undergoing as much exertion as at home, will demand as much food, and in the same proportions, as far as the four classes of aliment are concerned (and all physiological evidence goes to show that this must be the case, and that not external temperature, *per se*, but the work of the body, is the chief measure of food), the next question is, whether the different articles of the diet should be altered; whether, for example, the same amount of nitrogen being given, it should be contained in vegetable or animal food?

It has been stated by several of the best observers in the tropics that those who eat largely of animal food are less healthy than those who take more vegetable food; and Friedel, in his work on China, has again directed attention to the fact[1] that the amount of digestive and hepatic disease is much greater among the English than among any other European settlers in China. But whether this is owing to excessive animal food, or excess generally in all food, and to too much wine, beer, and spirits, is not certain. The diet is probably too rich as a whole.

Supposing meat is taken in proper but not excessive quantity with farinaceous food, as at home, is it less healthy than a quantity of vegetable food containing an equivalent amount of nitrogen? On this point strict scientific evidence has not been produced. With regard to excess of animal food there is no doubt; but animal food in moderation has not been shown to be more active in causing liver complaints in India than at home.

Considering, indeed, how important it is, when the digestive organs have been accustomed to one sort of diet, not to change it suddenly and completely, it seems very doubtful whether it would be desirable for the European arriving in India at once to give up all previous habits, and to commence an entirely different kind of diet.

It is possible, however, that the meat standard of England might be somewhat reduced, and the bread, flour, and leguminosæ increased. This is not the opinion, however, of some of those who have lately paid particular attention to Indian rations (Dr. C. A. Gordon and Dr. Inglis),[2] and who believe that the amount of meat is even too small.

It has often been said that Europeans in India should imitate the natives in their food, but this opinion is based on a misconception. The use of ages has accustomed the Hindu to the custom of taking large quantities of rice, with pulses or corn; put a European on this diet, and he could not at first digest it; the very bulk would be too much for him. The Hindu, with this diet, is obliged to take large quantities of condiments (peppers, etc.). The European who did the same would produce acute gastric catarrh and hepatic congestion in a very short time; in fact, as

[1] Already noticed as regards India and the Mauritius.
[2] Op. cit. and Army Medical Report, vol. v., p. 380.

already stated, one great fault of the diet of Europeans arriving in India is too great use of this part of the native diet.

Two points about the diet of India seem quite clear. One is, that spirits are most hurtful, and that even wine and beer must be taken in great moderation. Of the two beverages, light wines (clarets), which are now happily coming into use in India for the officers, are the best. For the men good beer should be provided, but it is important to teach the men moderation. The allowance per man per diem should never be more than a quart, and men would find themselves healthier with a single pint per day. But it would seem probable that, especially in the hot stations and seasons, entire abstinence should be the rule, and that infusions of tea and coffee are the best beverages.[1]

The other point is, that in the tropics there is perhaps even a greater tendency to scurvy than at home; the use of fruits, then, is of great importance, and, whenever practicable, the growth of fruit trees should be encouraged in the neighborhood of stations. In some stations (Mooltan) lime-juice has been issued with the greatest benefit when vegetables were scarce.

Health of the Troops.

India presents in many respects the same history as our other tropical possessions. In former years there was a large mortality among Europeans, attributed usually to the climate, instead of being put down to its proper causes, viz., a reckless mode of living amidst the most insanitary conditions. As years have passed, the same gradual improvement has occurred in India as in the West Indies. Habits have improved, and the conditions of life have been slowly altered for the better. This change has been going on for years, and there has been an astonishing progress since the mutiny. Much, no doubt, remains to be done, but the fall in mortality and in sickness has been so marked in all the Presidencies, as to lead us to hope that in a few more years the Indian service will, like the West Indian, be almost as healthy as the home service. It may seem rash to anticipate such a result, but an improvement as great has already taken place, for the mortality even now has fallen one-half, compared with that of thirty years ago. The following table shows this :—

Earlier Years.—Mortality of Europeans per 1,000 *of Strength.*

Years and Authorities.[2]	Bengal Presidency.	Bombay Presidency.	Madras Presidency.
1845–54 (Chevers)	63.38	60.20	59.20
1838–56 (Queen's troops alone—Balfour)	79.20	61.10	62.90
1806–56 (Company's troops alone—Indian Sanitary Commissioners)	74.10	66.00	63.50

[1] The drinks which the private soldier often buys in the bazaars in India are of the worst description; arrack mixed with cayenne and other pungent substances, or fermented toddy mixed with peppers and narcotics, or drugged beer, are common drinks. It would be easy to put a stop to this by legislative enactment.

[2] The chief statistics of the forces in India are contained in—

1. Numerous scattered papers in the various Indian medical periodicals for the last forty years, referring chiefly to the health of one presidency or of regiments or forces occupying small districts.

2. Summaries of the whole, by Colonel Sykes (for twenty years ending 1847, Sta-

In 1812–16, in the Bengal Presidency, the deaths averaged 96.5 per 1,000; in the Bombay Presidency, in 1819–20, the deaths were 80 per 1,000.

The above mean mortality includes every loss; in some years it was, of course, greater, in some less; but on the whole large every year, with a few exceptions, till the year 1856. After the mutiny, about the year 1860, the sanitary improvements and the greater care of the troops which had been gradually taking place received an immense impulse. The results are shown below.

Later Years.—Mortality of Europeans per 1000 *of Strength.*

Years and Authorities.	Bengal Presidency.	Madras Presidency.	Bombay Presidency.
	Total Mortality.	Total Mortality.	Total Mortality.
1860–9 (10 years—Balfour), . .	31·27	22·53	22·58
1870–79 (10 years—*A.M.D. Reports*),[1]	20·17	18·97	16·37
1880,[1]	29·26	10·51	25·10

Causes of Sickness and Death.

The causes of diseases and deaths of Europeans are given in the following table.[2] During the period of ten years there was a good deal of cholera in the years 1872 and 1875, 1876, 1878, 1879, as well as in 1880.

Admissions and Deaths per 1000 *of Strength.*

Causes.	Bengal.				Madras.				Bombay.			
	1870-79.		1880.		1870-79.		1880.		1870-79.		1880.	
	Adm.	Died.	Adm.	Died.	Adm.	Died.	Adm.	Died.	Adm.	Died.	Adm.	Died.
Cholera, .	6·3	3·2	6·8	4·9	3·6	1·5	0·1	0·1	2·1	1·5	...	...
Paroxysmal fevers	453·8	1·3	645·2	2·5	119·5	0·3	346·6	0·3	546·2	1·0	975·4	3·5
Continued fevers	164·1	2·4	160·6	3·5	132·8	1·6	104·0	1·2	132·8	1·9	148·9	4·0
Eruptive fevers (including Dengue), .	3·7	0·1	0·6	...	1·2	0·1	0·8	...	1·4	0·05	1·0	0·1
Rheumatism,	49·4	0·02	39·5	0·03	35·5	0·03	31·8	...	39·1	0·05	39·4	0·3
Syphilis, .	90·8	0·11	121·1		105·7	0·15	132·9	0·1	89·1	0·08	115·2	0·1
Phthisis, Scrofula, &c., .	9·0	1·6	7·5	1·8	10·5	1·6	7·3	0·9	8·3	1·55	6·7	1·5
Respiratory, .	58·3	1·1	51·1	2·1	42·0	0·5	35·0	0·7	42·6	0·1	58·0	2·3
Circulatory, .	20·0	1·3	14·6	0·8	18·9	1·7	17·8	1·2	13·5	1·0	12·2	0·5
Nervous, .	20·1	2·2	21·9	3·8	18·6	2·0	15·0	1·6	15·9	2·1	14·9	4·0
Eye, . .	20·6		16·3	...	18·2	...	16·1		20·7	...	16·7	...
Digestive, .	235·1	5·4	256·2	6·2	328·5	6·1	231·3	2·8	220·2	3·8	266·0	5·1
Urinary, .	118·2	0·3	136·8	0·2	88·5	0·2	131·3	0·1	98·2	0·2	131·0	0·5
Injuries and poisons, .	96·0	1·6	92·1	3·0	104·0	2·1	98·8	1·4	99·6	1·8	110·3	2·4
All other causes,	94·5	0·3	192·7	0·4	195·2	1·0	201·2	0·1	172·7	1·1	222·2	0·8
Total,	1439·9	25·0	1763·0	29·2	1226·9	18·9	1370·0	10·5	1503·4	16·0	2117·9	25·1

[1] Including deaths of invalids. [2] Army Medical Reports, vol. xii. to xxii.

tistical Journal, vol. x.); Sir Ranald Martin (Influence of Tropical Climates, 2d edition); Mr. Ewart (Vital Statistics of European and Native Armies, 1859); Drs. Waring and Norman Chevers (Indian Annals, 1858–1862); and as far as officers and civilians are concerned, by Col. Henderson (Asiatic Researches, vol. xx.), and Mr. Hugh Macpherson.

3. Official documents, the most important of which are contained in the Indian

The following table shows the distribution of mortality according to age :—

Deaths per 1,000 *of Strength at the Ages named.*

All India.	Under 20 years.	20 and under 25.	25 and under 30.	30 and under 35.	35 and under 40.	40 and upward.
1860–69 (10 years—Balfour).....	9.25	17.59	24.63	34.17	44.13	60.88
1870–79 (10 years).....	6.65	14.79	16.95	22.14	28.17	52.01
1880.....	10.59	23.17	21.70	26.56	25.59	45.50

If these numbers are compared with those of men serving at home, it will be seen that the mortality at every period is greater in India. If the average for the corresponding years in England be multiplied by three, the result comes close to the average Indian numbers in the earlier years, although the proportion is not quite the same in the later. In the period 1870–79 the ratio between the ages 20–30 is nearly three times the home ratio, while in 1880 it was about four times. At the ages above 30 the rate in India is distinctly diminishing.

These facts are an argument against the view that age, *per se*, increases the total mortality faster than it does at home ; and the statistics of officers confirm the inference drawn from the argument. The mortality of the members of the Military and Medical Funds in Madras and Bengal has been carefully determined by actuaries, and the following table proves that mortality among officers does not increase with age in anything like the proportion it does among non-commissioned officers and privates. The large mortality in the earlier ages is owing to the statistics running back to long periods, when the deaths were more numerous.

Mortality in Officers (in Service Fund) according to Age,[1] *per* 1,000 *of respective Ages.*

	Under 20.	20–25.	25–30.	30–35.	35–40.	40–45.
Madras Military Fund, 1808–57...	29	32.6	31.6	32	29.4	28.4
Bengal Military Fund.....	12	22.3	24.5	27.5	29	28.9
Madras Medical Fund, 1807–66....	..	14.2	35.1	34.1	33.4	34.1

The mortality among officers of 30 to 35 years of age was, therefore, nearly the same as among privates, but at 35 to 45 it was very much less.

Sanitary Report ; in the yearly Army Medical Department Reports since 1860 ; in the various Reports of the Sanitary Commissioners in the three Presidencies, in the invaluable Returns of the late Dr. Bryden, and in the Municipal and other Official Reports sent in from towns or districts. At present the most valuable information is being collected and published in India of the health not only of the European and native armies, but of the civil population ; and records of population and of births and deaths are now systematically made. For the first time the Indian Government is gradually obtaining a view of the state of health of the numerous nations it controls.

The Reports from Bengal (Annual Reports of the Sanitary Commissioner with the Government of India) and those from Madras and Bombay are models of their kind, and must have a great effect on the health of the inhabitants of all India. The information given in these excellent Reports is so copious that it is impossible to give any adequate account of it in this short chapter. Only the most striking points are noticed.

[1] Copied from the Report for 1871 of the Sanitary Commissioner (Dr. Cornish) for Madras, 1872, p. 7.

Mere climatic conditions, acting more and more as age advances, can therefore not account for the greater mortality of the private soldier, for they would act equally on the officer. No doubt the officer had a more frequent furlough to England; but would this be capable of giving him such an advantage? We must conclude that other conditions apart from, or at any rate superadded to, climate, must give rise to the large mortality of the private soldiers.

Mortality according to Service.

The question can be further considered by taking into account the effect of service. The following table from Dr. Bryden shows the effect of service for three years at the different ages:—

Death-rate per 1,000 *in the European Army of Bengal, excluding Cholera.*

	Under 20 years of age.	20–24.	25–29.	30 and over.
Whole army of 1865–70.....	7.61	13.67	17.41	29.94
First year of service.....	12.93	24.87	39.32	47.08
Second year of service.....	3.95	15.84	23.08	35.61
Third year of service.....	2.87	9.92	17.64	27.77

This table brings out very forcibly the great mortality of the first year of service at all ages; the older men suffer as much as the younger; the mortality falls during the second year of service, and in the third is below the mean mortality of the army at large. To determine how far this is owing to climate, we must analyze the causes of this mortality. The careful statistics of Dr. Bryden enable us to answer this point with some accuracy.[1]

Deaths in the first Two Years of Indian Service and the Death-rates at different Ages (1871–75).[2]

Causes of Death.	Died per 1,000 of Strength in the Biennial Period.			
	Under 24.[3]	25–29.	30–34.	35 and upward.
Cholera	5.34	5.87	4.77	13.86
Remittent and continued fevers.....	2.10	3.84	1.27	3.73
Enteric fever	9.77	10.16	1.59	0.53
Apoplexy.....	2.11	2.71	4.77	12.26
Dysentery and diarrhœa.....	1.80	3.39	3.82	11.20
Hepatitis	1.88	5.42	4.45	12.26
Phthisis pulmonalis	2.10	1.58	3.82	8.53
Heart diseases	0.15	2.26	3.82	9.06
All other causes	6.00	7.00	8.27	22.39
All causes	31.25	42.23	36.58	93.82
All causes, excluding cholera...	25.91	36.36	31.81	79.96

[1] See Appendix C, in Bengal Sanitary Report for 1870, p. 255 et seq., and for 1871, p. 213; also Vital Statistics of India, vol. v. Dr. Bryden's Statistics, as given in the Reports of the Sanitary Commissioner with the Government of India, and in the separate Blue Books (Vital Statistics of the Bengal Presidency, 1870 and 1878), are so much more complete than any other, that they have rendered obsolete all the older records. Dr. Cornish's Statistics as contained in the Madras Sanitary Reports are also most valuable.

[2] Vital Statistics of India (Bryden), 1878, vol. v., p. 56.

[3] The number of soldiers under 20 is now very small, little over 2 per cent.

100 *Deaths made up at different Periods of Residence in India* (1871–76).[1]

Disease.	1st Year.	2d Year.	In first four Years.	5th, 6th, and 7th Years.	Above the 7th Year.	Above the 10th Year.
Enteric fever	32.9	16.8	22.2	5.2	0.9	0.5
Hepatitis	10.1	17.6	14.0	18.9	16.0	15.7
Heat-apoplexy	12.7	9.7	11.8	11.9	10.3	9.5
Phthisis	7.7	10.9	9.0	8.1	8.2	7.8
Dysentery	9.6	10.4	9.0	10.1	13.3	13.7
Other fevers	8.9	8.3	7.8	7.3	6.0	4.6
Heart disease	5.3	7.5	5.8	11.2	16.2	17.6
Respiratory diseases	4.1	4.1	4.4	5.9	6.8	6.6
Suicidal deaths	1.2	3.7	2.1	6.1	5.2	6.1
All other causes (excluding cholera, small-pox, and accidents)	7.5	11.0	13.9	15.3	17.1	17.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

These tables are instructive on several points:—

1. As regards *fever:* the most serious mortality is from *enteric* fever, which attacks the young soldier, especially in his earliest term of service. The mean mortality below 30 years of age is, in round numbers, 10 per 1,000 of strength, from 30 to 35 less than *one-sixth* of that proportion, and above 35 only *one-thirtieth.* With reference to length of service, the first year in India shows that about 33 per cent. of the total deaths are due to enteric fever, and in the first *four* years 22 per cent.; from the fifth to the seventh the proportion is reduced to 5 per cent., while after 7 years it is merely fractional. The other fevers show much less difference.

2. *Heat-apoplexy.*—This formidable disease is most severe in the earlier years, and attacks especially the *old* soldier: the mortality above 35 years of age is 12½ per 1,000, *six* times the ratio below 24, and *five* times that below 30.

3. *Dysentery* and *diarrhœa* are more fatal to old soldiers, and in the later years of service.

4. The same is very markedly the case with *hepatitis,* which is markedly a disease of deterioration.

5. *Phthisis* is rather more fatal in the earliest years of service, but (in the period 1871–75) shows most mortality among the older soldiers. This, however, does not appear to be uniformly the case, if we compare previous years.

6. *Heart* diseases show, as might be expected, an increasing mortality with age and length of residence in India.

The most dangerous disease, therefore, which young newly arrived soldiers have to face in India is (putting aside *cholera* for the present) *enteric fever;* next to that, but at a considerable distance, *dysentery* and *diarrhœa.* These diseases, but most especially enteric fever, are so completely under the control of sanitary measures that their continuance is a slur upon the application of our sanitary knowledge. There is no reason to believe that proper preventive means should be less successful in India than at home. For old soldiers, that is, men over 30 years of age, newly

[1] From Bryden's Vital Statistics of India, vol. v., 1878.

arrived in India, the diseases to be feared are *heat-apoplexy, dysentery, hepatitis,* and *heart disease,* all diseases of deterioration, and favored and aggravated by intemperate habits. With careful medical selection of men much might be prevented, and hygienic precautions, such as free ventilation against heat-apoplexy, might do a great deal toward a diminution of the mortality. But drinking habits are the most dangerous enemy the soldier, particularly as he advances in years, has to contend with. The abolition of the sale of spirits to European soldiers, either in canteens or elsewhere, would be a great advantage.

Troops should be stationed in the hills as much as possible, so as to remove them from the influences of excessive heat, malaria, and choleraic poison, and also it might be hoped to some extent from enteric fevers. More efforts ought to be made to provide employment and recreation for the troops, who suffer greatly from enforced idleness, ennui, and the foul air of their barrack rooms, to which they are still too much confined for fear of exposure to the sun. Undue exposure is unadvisable, but it may be safely said that its consequences are smaller evils than those undoubtedly arising from the mistaken steps taken for their prevention.

The men ought also to be spared as much as possible from unnecessary night duty.

As regards age of arrival in India, men cannot now be sent out under 20 years of age, for, as they are not taken into the army before 19, their preliminary training will not be over before that age: there is also now an order against it. Above that age the younger they go the better. For the first years, if protected from enteric fever, cholera, and dysentery (which is quite possible), their health will be as good as, if not better than, at home. It seems pretty clear, on the other hand, that men ought not to remain beyond 30 years of age, if possible, unless they are non-commissioned officers: the best period would appear to be between 21 and 28 years. After 30 years of age the private soldier is an old man in India (Bryden, Roberts), and this is partly due to the work he has had to do (particularly night guards—Roberts), but also very largely to habits of drinking. When we find, as in the army of Bengal, 30,000 men yielding 10,000 cases of drunkenness in the year, we cannot but consider it a deplorable condition of things, knowing as we do what a large amount of unrecorded excess this represents.

Cholera in the Bengal Presidency.[1]

During fifty years (from 1818 to 1867) the mean annual mortality from cholera per 1,000 of European strength in Bengal was no less than 9.4. It was the great cause of variation in the percentage of mortality from year to year. The cholera mortality was not owing, as might have been supposed, to service in the stations in Bengal proper (the so-called endemic home of cholera), for the mean mortality in Bengal proper was below that of the Punjab, where cholera is occasional, *i.e.*, prevails only at certain seasons and in certain years. If we compare Bengal proper with two other military districts, Agra (with Central India) and the Punjab, two facts come out very clearly—(1) That in Bengal proper the mortality is more steady, but on an average of years is lower than in the other two districts, where the mean mortality is heightened by occasional tre-

[1] The statistics referred to in this section are those given by Bryden in his valuable Reports (Vital Statistics of the Bengal Presidency, 1870 and 1878), and Appendices from Dr. Cuningham's Annual Report.

mendous outbreaks unknown in cholera's endemic home; (2) that in Bengal proper the Sepoy mortality is higher than in Europeans, while in the other stations it is much lower.[1]

Table to show the Mortality from Cholera per 1,000 *of Strength in Europeans and Sepoys.*

Years.	Bengal Proper.		Agra and Central India.		Punjab.	
	Europeans.	Sepoys.	Europeans.	Sepoys.	Europeans.	Sepoys.
1861	6.51	6.38	41.21	0.25	36.10	6.88
1862	6.11	5.44	26.90	1.3	12.74	3.99
1863	3.17	4.25	3.82	0.4	0.13	0.90
1864	2.50	6.40	0.62		0.06	0.09
1865	6.40	9.20	7.20	3.1	0.14	
1866	1.90	7.03	0.23			
1867	2.50	3.50	3.30	0.9	20.70	3.9
1868	5.34	2.51	3.36	0.16		
1869	0.53	4.43	30.18	7.25	16.86	7.33
1870	1.00	3.03	0.47			
1871	0.51	1.25	0.24			
1872	1.01	2.70	4.75		13.86	2.80
1873	0.53	2.76	0.97	1.05		
1874	0.50	4.74		0.26	0.09	0.07
1875		2.76	5.57	1.57	2.27	1.50
1876	2.49	2.01	0.25		4.48	1.80
Means	2.12	4.27	7.46	1.01	5.63	1.83

This table is most instructive, and proves beyond doubt that while cholera has never (until lately) been absent from Europeans in Bengal proper[2] (the endemic home), it has never attained the destructive prevalence which occurs in Central India and the Punjab, where it is sometimes entirely absent for years, and yet the severity of the outbreak, when it does occur, makes the mean Punjab and Central India cholera mortality of sixteen years far greater than the cholera mortality of Bengal proper.

Among Sepoys the mortality in Bengal proper is actually greater than in Europeans, while it is far less in the Upper Provinces, and in some outbreaks (as in Central India in 1861) the Europeans have suffered frightfully, while the Sepoys have been scarcely touched.

What, then, is the cause that while in Bengal proper, where the conditions of cholera always exist, the mortality should be comparatively low, there should be such terrible outbreaks in up-country stations where cholera is only a visitor, and why should these outbreaks affect the Eu-

[1] It has been wrongly stated that the excessive mortality from cholera of Europeans in the Bengal Presidency is an effect of race; the statistics of Bengal proper (as shown in the next table) and of the Madras Presidency entirely disprove this. In the Madras Presidency in 1860–66, the annual European cholera mortality was 3.1 per 1,000 of strength, and the Sepoy mortality was 3.07, or virtually the same.

[2] Since 1876 the ratio of deaths from cholera among European troops has been very small in the Presidency division (including Bengal proper):—

1877 0.49 per 1,000.
1878 0.97 "
1879 nil. "
1880 nil. "

ropeans so particularly? To answer this question we may select a few of the worst stations in Upper India, and see what the mortality was in the epidemics of 1861–62–67–69–72–75–76.

Mortality per 1,000 *of European Strength in different Epidemics.*

	1861.	1862.	1867.	1869.	1872.	1875.	1876.
Meerut	34.32	15.70	70.30	7.04	32.62	7.35	
Mean Meer.	245.63	49.93	50.49		86.87	1.90	
Peshawur ..		49.24	92.93	120.14	21.53		23.06
Agra	56.56	42.5			15.57		
Morar	137.43	37.25	11.52	82.89	17.05	17.05	

This table shows that the outbreaks are very variable in intensity; a station may be quite free from cholera in one epidemic and suffer frightfully in another. In Agra, in 1861–62, there were seven outbreaks; in 1867 and 1869 there was no case, though the disease was all round.

If we analyze the station statistics themselves, the remarkable fact comes out that some of the severest outbreaks involved only a portion of the Europeans.

At Meerut, in 1867, while the 3d Buffs were literally more than decimated, the Hussars and Sepoys were as healthy as if they had been in England.

These facts show that the hypothesis of an epidemic influence produced by something floating in the air is incredible, and for such a partial distribution as is shown above would be impossible. If these figures prove anything, it is that the causes of the tremendous loss in these stations is not a generally diffused cause, but a well-marked local development, having narrow limits, and sometimes involving only a single barrack.

The figures also show that the supposition that the difference in mortality between the Europeans and Sepoys is owing to difference of social habits (especially as regards latrine arrangements) is unlikely, for different bodies of Europeans in the same station suffer as diversely as Europeans and Sepoys.

The localizing conditions, which give the intense spread to what is, no doubt, an imported agent, must be referable to either soil, water, air, or food. Faulty latrine arrangements, if they exist, must act through one or other of these media, poisoning the ground, or air, or water. The inquiry into the local spread of cholera, if concentrated on the locality, and carried to the exhaustion of every possible factor, must surely solve this problem. It is as in typhoid fever at home, where everything often seems a mystery until a minute search is made, and then what seemed inexplicable is found to be simple.

But, without waiting for the solution of the cause of these localizations of cholera, the fact of the localization points out preventive measures which, as a matter of reasonable precaution, ought to be taken in every barrack in Upper India where these great outbreaks have occurred. These measures should be adopted on the ground of removing every possible local cause, even though the particular precaution may not have been *proved* to be necessary.

1. The influence of the ground should be excluded by the most thorough paving and cementing everywhere, and by careful examination

and cleansing under every floor. When possible ground floors should not be occupied as sleeping rooms.

2. A fresh-water supply should be obtained at any cost, be from an undoubted source, and be kept solely for the use of the barrack. During an epidemic all water should be boiled before use, or, better still, distilled.

3. The cooking arrangements should be entirely remodelled, and the supply of every article of food carefully considered.

4. The latrine arrangements should be remodelled, the places changed, and the system at every point scrutinized to see if soil, air, or water can in any way be contaminated by percolation or emanation.

If, after adopting these measures, and carrying them out fairly in their integrity, an outbreak still occurs, this cannot throw doubt on the correctness of the view which attaches so much weight to localization; it will only show that we have not solved the problem of the localizing agency, and if no other local sanitary measures can be adopted the barrack should altogether be abandoned. But this will hardly be found to be necessary.

With regard to Mean Meer, which has suffered so severely and so often from cholera, it is a very important fact that enteric fever has from time to time prevailed at that station, as in 1860-69-70. In the two latter years a careful examination of the water supply was made by Surgeon-Major Skeen, of the 85th Regiment, who formerly gave evidence on the point, that in both these years the water was the medium of introduction. The fact of typhoid fever being thus introduced by well-water (temporarily used in the absence of canal-water), the chemical analysis showing fecal impregnation of this well-water, and the existence of sources of fecal contamination of water, all seem strongly to indicate that cholera evacuations would also, in all probability, pass into the water, and might account for the fearful outbreaks at Mean Meer. At any rate, there can be no doubt that means should be taken to entirely close the wells, which are occasionally used, and if the canal-water which is ordinarily used does not give a sufficient supply at all times of the year, that a fresh source should be brought down at any cost. The strong facts given by Dr. De Renzy respecting Peshawur prove that the same course should be adopted in that station. These measures are imperatively demanded as a matter of precaution, and no theoretical arguments that the water is not to blame ought to be allowed to override them. The diminution of cholera at Calcutta among Europeans since the introduction of a pure water supply and improved drainage is very encouraging for the strenuous application of local measures.

Phthisis in India.

The amount of phthisis in India is a highly interesting question, and in the table on page 355 the admissions, deaths, and invaliding from this cause are given for successive periods.

How regularly the causes of phthisis must be acting is seen in the fact that in four years, 1863-66, 74 men died from phthisis in the Bombay Presidency, and 73 in the Madras Presidency, the mean number of troops being in each case almost precisely the same (12,119 and 12,512). In the next four years, with a smaller number of troops, 53 and 55 died in the two presidencies. The means of deaths (for 18 years) and invaliding (12 years) are practically identical for Madras and Bombay as shown above. In the Bengal Presidency the deaths are higher, but the invaliding is less, so that the slight difference is compensated. More men died, and fewer were sent away.

Phthisis, including Hæmoptysis, per 1,000 *of Strength.*

	Admissions.	Deaths.	Invalided.[1]	Total Deaths and Invalided.[1]
BENGAL.				
4 years—(1863–66).....	7.5	1.71	2.73	4.44
4 years—(1867–70).....	10.1	1.75	3.64	5.39
6 years—(1869–74).....	10.1	1.87		
6 years—(1875–80).....	7,8	1.48		
BOMBAY.				
4 years—(1863–66).....	7.7	1.52	3.28	4.81
4 years—(1867–70).....	9.2	1.23	3.58	4.81
6 years—(1869–74).....	10.0	1.67		
6 years—(1875–80).....	6.7	1.25		
MADRAS.				
4 years—(1863–66).....	11.5	1.46	3.66	5.11
4 years—(1867–70).....	11.9	1.34	4.74	6.07
6 years—(1869–74).....	13.0	1.62		
6 years—(1875–80).....	8.1	1.37		
Means, 18 years (1863–80)				
Bengal	8.7	1.68	2.97	4.64
Bombay	8.2	1.40	3.74	5.08
Madras	10.8	1.44	3.73	5.02

The table seems to show clearly that the immense range and variation of climates in which the troops serve in India produce no effect whatever on the production of phthisis; and this inference is again strengthened by the fact that the mortality in Bengal from phthisis is precisely the same as in Canada (1.71 per 1,000). The means for 12 years (1869–80) were—Bengal, 1.37; all India, 1.30; Canada, 1.37.

If the Indian mortality and invaliding are compared with the table already given of phthisis in the home army, it will be seen that there is decidedly less phthisis in India. The mortality is less, and the invaliding is far below. There can be no doubt, then, that the causes of phthisis are less active in India than at home; and if these causes are not climatic, must the difference not be found in the larger breathing space and greater lateral separation men have in India?

It would be interesting to have some certain statistics of the amount of phthisis in former years, when men were more crowded; Ewart[2] gives the deaths in the Bengal Presidency, from 1812 to 1831, as 2.6 per 1,000 of strength, and from 1832 to 1851–52, as 1.8 per 1,000. In the Bombay Presidency, from 1803 to 1827, they were 1.6, and from 1828 to 1852, 1.4 per 1,000. Ewart thinks this indicates a large decrease, but doubts whether this may not be owing to more accurate diagnosis. The table just given shows, however, that in Bombay at any rate the deaths in the years 1863–

[1] 1871–74 and 1877–78 omitted. [2] Vital Statistics of the Armies in India, 1859, p. 164.

80 were as great as in 1828–52. In Bengal there is a diminution, but it is very slight. In the early period, however, there may have been less invaliding. In the absence of reliable statistics, the question of the relative amount of phthisis now and formerly seems impossible to be answered.

With respect to the cure and prevention of phthisis, it seems a great pity to send phthisical invalids to England, where they die at Netley, or are cast out to die miserably among the civil population, when in the Himalayas there are elevated localities which must be particularly adapted for the successful treatment of consumption. When means of communication are improved, it is possible that we may see phthisical invalids going from Europe to the high peaks of the Himalayas, and why should not the European soldier, who is actually in India, benefit by the mountain ranges? A phthisical sanitarium, at an altitude of 10,000 feet, would be likely to cure the disease in many cases, if it were diagnosed early, and then if the men were afterward kept on the lower hill stations, they would probably become perfectly strong. To send these men home to England, is condemning them to almost certain death. Formerly the distance in India would have been fatal to such a plan, but now, by proper arrangements, even weakly men could be brought from all parts of India. Dr. Hermann Weber, who has paid great attention to the effect of altitude on phthisis, holds very decided views as to the beneficial effect of such an arrangement, and has already urged this point on the attention of the authorities.

The other diseases of the lungs are not unknown in India. Pneumonia gives a mortality in Bengal of about 0.5 per 1,000 of strength, or a little less than at home (= 0.571); while in the other two presidencies it is not half this amount. Acute bronchitis also causes in all the presidencies a mortality almost precisely the same as at home (0.27 and 0.285 per 1,000).

Loss of Service—European Troops.

The admissions and mean daily sick have been already given.

As compared with home service, a larger number of admissions, a greater daily number of sick, and a shorter duration of cases and a larger mortality, indicate not only more sickness, but the presence of very rapid mortal diseases, which shorten the mean duration of all cases.

The chief causes of admissions are "paroxysmal and continued fevers," venereal disease, dysentery, rheumatism, integumentary diseases, and digestive affections (not hepatitis). Hepatitis and cholera cause few admissions, but a large mortality.

It is most satisfactory to find that the sickness and mortality are both rapidly falling, owing to the energetic means now being adopted by the Government, and to the increased sanitary powers and improved curative means of the medical officers.

The prevalence of venereal disease demands as much attention in India as in England, but the preventive measures will be much easier. Police regulations and proper surveillance are now being enforced, and Lock hospitals are established in many places.

Invaliding of European Troops.

For some years back the invaliding statistics of Bengal have been given with great care by the late Dr. Bryden.[1] The invaliding ratio, from all

[1] Vital Statistics of the Bengal Presidency, 1870 and 1878; and Reports of the Sanitary Commissioner (Dr. Cuningham) with the Government of India. Reference must be made to these elaborate reports for the full details.

causes, in the Bengal European army, varied in ten years (1861–70) from 28.09 to 53.98 per 1,000 of strength, the mean being 38.9; and in the next ten years (1871–80) from 29.88 to 47.14, the mean being 40.6.

In the Bengal army the ratios were per 1,000 strength—

Years.	Under 25.	25 to 30.	30 and upward.
1865–70.....	26.55	39.74	78.34
1871–75.....	24.60	35.92	58.17

Army of India.

Years.	Under 25.	25 to 34.	35 and upward.
1871–75.....	25.84	37.07	91.34

Bryden remarks that there is but little change in the invaliding rate from 25 to 34 years of age, and he therefore puts the ten years in one class.

The invaliding is high during the early years of service, as shown by the following table:—

Invaliding per cent. of the total Invaliding at the different Periods of Indian Service, 1871–75.

1st and 2d years.....	28.5	1–4	48.1
3d and 4th "	22.3	5–7	23.2
		above 7	28.7
			100.0

The chief causes of invaliding are phthisis, heart affections, hepatitis, and general debility, and the following table, calculated from Bryden, shows the ratio of these classes (1871–75):—

Chief Causes for Invaliding.	1 to 4 Years.	5 to 7 Years.	Above 7 Years.
Phthisis.....	11	9	6
Heart affections.....	15	10	6
Hepatitis.....	15	17	16
General debility.....	15	20	29
Per cent. of total invaliding at each period.....	56	56	57

The total invaliding is made up of those sent home for discharge and for change of air. From about 30 to 60 per cent. of all invalids are in the latter category. In the ten years, 1870–79, the mean number of invalids sent home was 42.44, and those finally discharged were 16.08 per 1,000 of strength. Those sent home for change were thus 62 per cent. of the whole. In 1880, 29.88 per 1,000 were sent home and 21.40 discharged, the percentage sent home for change being thus only 28½.

Mortality of Native Troops.

Colonel Sykes gives the mortality for 1825–44 as 18 per 1,000 of strength for all India; and for Bengal, 17.9; Bombay, 12.9; Madras, 20.95.

In Madras, from 1842 to 1858, the average was 18 per 1,000 (Macpherson), of which 6 per 1,000 each year were deaths from cholera.

Ewart gives the following numbers per 1,000 of strength—Bengal (1826–1852), 13.9; Bombay (1803–1854), 15.8; Madras (1827–1852), 17.5.

Taking successive quinquennial periods, there has been a slight progressive decrease in mortality, but this is less marked than in Europeans.

The excess of mortality is chiefly due to cholera, dysentery, and fever.

In Bengal, in the years 1861–67, the annual mortality per 1,000 of men present with the regiments was 14.57. In Madras the average mortality in six years, 1860–66, was 12.6.

The following table gives the mortality of native troops per 1,000 of strength for the period 1867–76, from Bryden's tables:—

Mortality of Sepoys (1867–76) *per* 1,000 *of Strength.*

Diseases.	Bengal.
Cholera	2.12
Fevers	2.84
Heat-apoplexy	0.22
Dysentery and diarrhœa	2.01
Hepatitis	0.15
Spleen diseases	0.28
Respiratory diseases	2.57
Heart disease	0.20
Phthisis pulmonalis	0.77
Dropsy	0.09
Scurvy	0.14
Atrophy and anæmia	0.52
All other causes	1.19
Violent deaths	0.74
Total deaths	13.84
Deaths, excluding cholera	11.72
Total deaths, including those in absence	17.25

SECTION IX.

CHINA.

Hong-Kong.

Although the English have occupied Canton, Tientsin in the north, and several other places, yet, as their occupation has been only temporary, it seems unnecessary to describe any other station than Hong-Kong.

Garrison of Hong-Kong about 1,000, but differing considerably according to the state of affairs in China.

The island is 27 miles in circumference, 10 long, and 8 broad at its widest part.

Geology.—The hills are for the most part of granite and syenite, more or less weathered. In some parts it is disintegrated to a great extent, and clayey beds (laterite) are formed, in which granite boulders may be embedded. Victoria, the chief town, stands on this disintegrated granite. As in all other cases, this weathered and clayey granite is said to be very absorbent of water, and, especially in the wet season, is considered very unhealthy.

Climate.—Mean annual temperature, 73° Fahr. ; hottest month (July), 86.25° ; coldest month (January), 52.75° ; amplitude of the yearly fluctuations, 33.5°.

The humidity is considerable—about 80 per cent. of saturation, as an average.

The N.E. monsoon blows from November to April ; it is cold, dry, and is usually considered healthy and bracing ; but if persons who have suffered from malaria are much exposed to it, it reinduces the paroxysm. The S.W. monsoon blows from May to October ; it is hot and damp, and is considered enervating and relaxing. The difference in the thermometer between the two monsoons has been said to be as much as 46°, but this seems excessive.

The rainfall is about 90 to 100 inches with the S.W. monsoon.

In addition to Victoria, there are two or three other stations which have been occupied as sanitaria, viz., Stanley, seated on a peninsula on the south end of the island, and about 100 feet above the sea ; and Sarivan, 5 miles east of Victoria. Neither station seems to have answered ; the barracks are very bad at Stanley, and are exposed too much to the N.E. monsoon, which, at certain times, is cold and wintry ; during the S.W. monsoon it is healthy. Sarivan has always been unhealthy, probably from the neighborhood of rice-fields. Since the close of the last war a portion of the mainland, Cowloon, opposite Victoria, has been ceded, and has been occupied by troops. It is said not to be, however, even so healthy as Hong-Kong,[1] but there are differences of opinion on this point.

Hong-Kong has never, it is said, been considered healthy by the Chinese. The chief causes of unhealthiness appear to be the moist laterite and weathered granite, and the numerous rice-fields. Indeed, to the latter cause is ascribed by some (Smart)[2] the great unhealthiness, especially when the rice-fields are drying in October, November, and December.

Local causes of unhealthiness existed till very lately in Victoria. In building the barracks the felspar clay was too much cut into, and, in addition, the access of air was impeded by the proximity of the hills. The S.W. monsoon was entirely shut out. Till lately sewerage was very defective.

Owing probably to these climatic and local causes, for many years after its occupation in 1842, Hong-Kong was excessively unhealthy. Malarious fevers were extremely common, and not only so, but it is now known that typhoid fever has always prevailed there (Becher and Smart). Dysentery has been extremely severe, and has assumed the peculiar form of lientery. This was noticed in the first China war, and appears, more or less, to have

[1] See Report of Surgeon Snell, Army Medical Report, vol. v., p. 360, for the causes of the unhealthiness of Cowloon.

[2] Transactions of the Epid. Soc., vol. i., p. 191. This paper should be consulted for an excellent account of Hong-Kong, and of the diseases among sailors especially.

continued since. In addition to these diseases, phthisis appears to have been frequent.

For some years there were such frequent wars in China, that the exact amount of sickness and mortality, due to the climate of Hong-Kong, could not be well determined. But it is becoming much healthier than in former years, owing to the gradual improvement in sanitary matters which goes on from year to year. In 1865 there was, however, much sickness, owing apparently to overcrowding and to bad accommodation.

In the "Statistical Reports," the troops serving in Hong-Kong, Cowloon, Canton, Shanghai, and the Straits settlements, are classed together, so that the influence of Hong-Kong *per se* can only be partially known.

In the years 1859–66, which include years of war, the admissions in South China averaged 2,131, and the deaths 56.25, or, exclusive of violent deaths, 52.63 per 1,000 of strength, and there was in addition a large invaliding. Paroxysmal fevers gave 609 admissions and 7.77 deaths; continued fevers, 25.25 admissions and 4.17 deaths; and dysentery and diarrhœa, 249 admissions and 16.3 deaths per 1,000. In later years the mortality was less; in 1869–70, it was 16.02, and in 1871 only 5.82 per 1,000 of strength, and of these only 3.88 was from disease. In the five years, 1871–75, it was 11.73; and in 1876–80 it was 8.61, giving for the ten years a mean of 10.17. This contrasts very favorably with the mean of the previous ten years (1861–70), which was 39.84, or nearly *four* times as great. It is evident that the causes of sickness and mortality are now being brought under control.[1]

[1] *Australia and New Zealand* —The withdrawal of the troops from these colonies renders it unnecessary to give any statistical details.

CHAPTER V.

SERVICE ON BOARD SHIP.[1]

SERVICE on board ship must be divided into three sections, corresponding to three different kinds of service.

1. Transport ships, for the conveyance of healthy soldiers, their wives and children, from place to place, or for conveying small parties of troops in charge of convicts.

2. Transports for conveyance of sick from an army in the field to an hospital in rear, or from a foreign station to a sanitarium, or home. Although the term is a little odd, it is convenient to call these ships Sick-Transports.

3. Hospital ships, intended for the reception and treatment of the sick.

SECTION I.

TRANSPORTS FOR HEALTHY TROOPS.[2]

The use of Government transports has very much altered the duty of medical officers on board. The transports are really men-of-war, *i.e.*, officered by the Royal Navy and under naval regulations. The medical officer of troops has therefore nothing to do with the vessel and its arrangements. If hired transports are used, the "Queen's Regulations" (1881) (section 17, Movement of Troops by Sea), and the "Medical Regulations" (Part I., section iii., sub-section iii.; Part II., section vi., sub-section x.; Part V., section vii.), have to be carried out.

SECTION II.

TRANSPORTS FOR SICK TROOPS.

No specific regulations are laid down with respect to these hired ships, but it would be very desirable to have some set rules with respect to space, diet, and fittings. Invalids are now carried from India and the Colonies in Government transports; occasionally hired transports are used. At

[1] See Rattray's paper read to the Medico-Chirurgical Society in 1872; also the last edition of this work; and Naval Hygiene, by Professor Macdonald, R.N., M.D., F.R.S. (Smith, Elder & Co.), 1881.

[2] The following note is given in the Queen's Regulations, 1881, p. 372: "*A Troop-Ship* is one of Her Majesty's ships commissioned as a troop-ship. *A Transport* is a ship wholly engaged for the Government service on monthly hire, or a ship wholly engaged by the Government to execute a special troop service, though not hired by the month. *A Troop Freight Ship* is a ship in which conveyance is engaged by Government for troops, but which is not wholly at the disposal of the Government."

present the diet of invalids on board the hired transports is not good. In respect of fittings, the use of swinging cots for feeble men and well-arranged closets for dysenteric cases are very important. So also with the cooking; the coarse ship cooking is a great trial to many patients. If there is need of Government transports for healthy men, the necessity is still greater for sick men.

As far as possible, the sick should be treated on deck in fine weather, a good awning and a comfortable part of the deck being appropriated to them. I believe that it would be a good plan not to send home officers and sick men in the same ship, but to have officers' ships, so as to give up the poop to the men in the ships which carried them. This division will be a gain to both.

In time of war, sick-transports are largely used to carry troops to hospitals in the rear. For this purpose good roomy steamers must be chosen. For economy's sake, they will generally be large, and probably with two decks; they should never have more, and indeed a single deck is better. But if with two decks, each space should be separately ventilated by tubes, so as, as far as possible, to prevent passage of foul air from the lower to the upper deck. All the worst cases should be on the upper deck, especially surgical cases.

The decks of these vessels should be as clear as possible, so that men can be treated on deck. An apparatus should be arranged for hoisting men on deck from below.

It has been proposed to fit these ships with iron bedsteads, and no doubt this gives the men more space; but a better plan still would probably be to have short iron rods, to which every cot could be suspended. The sick men might be carried in their cots on board, and again removed. If the rods are made about 14 inches high, and bent in at the top so as to form a hook, a cot is hung easily, and will swing. There is space enough below to put a close-stool or pan under the man without stirring him, if a flap is left open in the canvas, and a hole left in the thin mattress.

Fixed berths are not so good, but some must be provided. Some cots can swing from the top, and some men can be in hammocks. Probably every sick-transport should have all these, viz., iron bedsteads at some points fastened to the deck, iron standards for swinging cots, cots swinging from the roof, low berths, and hammocks.

In these sick-transports the kits and clothes must be stowed away; and as they are often very dirty and offensive, and sometimes carry the poison of typhus and other diseases, the place where they are put should be constantly fumigated with nitrous and sulphurous acid alternately. Robert Jackson mentions that dirty clothes and bedding may be soon washed sweet by mixing oatmeal with salt water.

Directly a sick-transport has landed the sick, the whole place should be thoroughly washed and scraped, then the walls and ceiling should be lime-washed, and the between-decks constantly fumigated till the very moment when fresh sick embark.

SECTION III.

HOSPITAL SHIPS.

These are ships intended for the reception and treatment of the sick—floating hospitals, in short. Whenever operations are undertaken along a sea-board, and especially when a force is moving, and places for fixed hos-

pitals cannot be assigned, they are indispensable. They at once relieve the army from a very heavy encumbrance, and, by prompt attendance which can be given to the sick, save many lives. They should always be organized at the commencement of a campaign. In the Abyssinian war three hospital ships were used. Their fitting out was carefully superintended by Deputy Inspector-General Dr. Massy, and appears to have answered admirably. A full account of one of these ships (Queen of the South) was given by the late Staff-Surgeon Charteris, to which reference may be made. The ventilation, as shown by the amount of carbonic acid (0.708 per 1,000 volumes), was very good. The superficial space between decks per man was on the night of the experiment 154 feet, and the cubic space no less than 1,076. During the Ashanti war (1873–74) the line-of-battle ship Victor Emanuel was used as an hospital ship, and was most successful. A very full and detailed account of it is given by the late Brigade-Surgeon T. M. Bleckley, C.B., in medical charge.[1] The floor-space per head was generally about 50 square feet, and the cubic space about 480, although it was originally intended to be less. Hospital ships were also used during the Egyptian campaign of 1882.

However convenient, and indeed necessary, they are, it must be clearly understood that they are not equal to an hospital on shore. It is impossible to ventilate and clean them thoroughly. The space is small between decks. The wood gets impregnated with effluvia, and even sometimes the bilge is contaminated. Dr. Becher, late pathologist in China, stated that even in the very best of the hospitals used there, it was quite clear that in every wound there was evidence of a slight gangrenous tendency. In fact, it is perhaps impossible to prevent this, except by the freest ventilation and the most vigorous antiseptic treatment.

The principle of separation should be carried out in these ships—one ship for wounded men, another for fevers, a third for mixed cases; or if this cannot be done, separate decks should be assigned for wounded men and fever cases. In fine weather the sick should be treated on deck under awnings. The between-decks must be thoroughly ventilated, and all measures of fumigation, frequent lime-washing, etc., must be constantly employed. Charcoal, also, in substance should be largely used. Warming by stoves must be used in damp and cold weather, and, if so, advantage should be taken of this source of heat, and of all lights, to improve ventilation.

Ships of one deck are better than two; but as they will hold a very small number of sick, two decks are commonly used. But not more than two decks should be used; and if there be a third or orlop deck, it should be kept for stores. Sometimes, if there are two decks, the upper deck is used for officers and the lower for troops, but the reverse arrangement should be adopted.

The ventilation of the between-decks, in addition to Edmond's plan, should be carried on by tubes, which, if the central shaft is acting, will be all inlets, and can be so arranged as to cause good distribution of the air.

The fittings of an hospital ship should be as few and simple as possible, and invariably of iron. Tables should be small, and on thin iron legs. Swinging cots are indispensable for wounded men, and the appliances for the receiving and removing the excreta of dysenteric and febrile patients must be carefully attended to. Berths should not be of wood, but of iron bars, which are much more easily laid bare and cleaned.

The supply of distilled drinking-water should be as large as possible,

[1] Army Medical Reports, vol. xv., p. 200.

and a good distilling apparatus should be on board, whether t
a steamer or not.

The laundry arrangements are most important, and it woul
plan, on a large expedition, to have a small ship converted en
laundry. It would not only wash for the sick, but for the healt
So also a separate ship for a bakery is an important point, so a
baking on board the hospital ship.

On board the hospital ship there should be constant fumig
washing, whenever any part of the hospital can be cleaned for
and, in fact, every other precaution taken which can be though
the floating hospital equally clean, dry, well aërated and pure as
on shore.

On board hospital ships it is often easy to arrange for sea-
douching; it should never be forgotten what important cur
these are.

In case pyæmia and erysipelas, or hospital gangrene occu
must be treated on deck, no matter how bad the weather may
awnings to protect from wind and rain can be put up.

If cows or goats are kept on board to supply milk, their st
kept thoroughly cleaned. But generally it is better to obtai
the shore.

CHAPTER VI.

WAR.

The trade of the soldier is war. For war he is selected, maintained, and taught. As a force at the command of a government, the army is also an agent for maintaining public order; but this is a minor object, and only occasionally called for, when the civil power is incompetent.

In theory, an army should be so trained for war as to be ready to take the field at literally a moment's notice. The various parts composing it should be so organized that, almost as quickly as the telegram flies, they can be brought together at any point, prompt to commence those combined actions by which a body of men are moved, fed, clothed, kept supplied with munitions of war, maintained in health, or cured if sick, and ready to undertake all the engineering, mechanical, and strategical and tactical movements which constitute the art of war.

That an organization so perfect shall be carried out, it is necessary that all its parts shall be equally efficient; if one fails, the whole machine breaks down. The strength of a chain is the strength of its weakest link, and this may be said with equal truth of an army. Commissariat, transport, medical, and engineering appliances are as essential as the arts of tactics and strategy. It is a narrow and a dangerous view which sees in war merely the movements of the soldier, without recognizing the less seen agencies which insure that the soldier shall be armed, fed, clothed, healthy, and vigorous.

During peace the soldier is trained for war. What is meant by training for war? Not merely that the soldier shall be taught to use his weapons with effect, and to act his part in that machine, where something of mechanical accuracy is imprinted on human beings, but that he shall also know how to meet and individually cope with the various conditions of war, which differ so much from those of peace.

It is in the nature of war to reinduce a sort of barbarism. The arts and appliances of peace, which tend, almost without our care, to shelter, and clothe, and feed us, disappear. The man reverts in part to his pristine condition, and often must minister as he best may to his own wants. No doubt the State will aid him in this; but it is impossible to do so as completely as in peace. Often, indeed, an army in war has maintained itself in complete independence of its base of supplies, and in almost every campaign there is more or less of this independence of action.

In peace, the soldier, as far as clothing, feeding, shelter, and cleanliness are concerned, is almost reduced to the condition of a passive agent. Everything is done for him, and all the appliances of science are brought into play to save labor and to lessen cost. Is this the proper plan? Looking to the conditions of war, ought not a soldier to be considered in the light of an emigrant, who may suddenly be called upon to quit the appliances

of civilized life, and who must depend on himself and his own powers for the means of comfort, and even subsistence?

There is a general impression that the English soldier, when placed in unaccustomed circumstances, can do nothing for himself, and is helpless. If so, it is not the fault of the man, but of the system which reduces him to such a state. That it is not the fault of the man is shown by the fact that, however helpless the English soldier may appear to be in the first campaign, he subsequently becomes as clever in providing for himself as any man. The Crimean war did not perhaps last long enough to show this, but the Peninsular war proved it. The soldier there learned to cook, to house himself, to shelter himself from the weather when he had no house, to keep himself clean, and to mend and make his clothes. Was it not the power of doing these things, as well as the mere knowledge of movements and arms, which made the Duke of Wellington say that his army could go anywhere and do anything? And the wars at the Cape and in New Zealand have shown that the present race of soldiers, when removed from the appliances of civilized life, have not lost this power of adaptation.

The English soldier is not helpless; he is simply untrained in these things, and so long as he is untrained, however perfect he may be in drill and manœuvre, he is not fit for war. The campaign itself should not be his tutor; it must be in the mimic campaigns of peace, in which the stern realities of war are imitated, that the soldier must be trained. Our present field-days represent the very acme and culminating point of war—the few bright moments when the long marches and the wearisome guards are rewarded by the wild excitement of battle; but the more common conditions of the campaign ought also to find their parallel. Since the Crimean war much has been done to instruct the soldier in the minor arts of war. The establishment of camps has to some extent familiarized him with tent life; the flying columns which go out from Aldershot show him something of the life of the bivouac, and the training in cooking which Lord Herbert ordered is teaching him how to prepare his food. The Autumn Manœuvres have extended this system, and are now making him familiar with the chief conditions of the life in campaigns.

A campaign can never be successful unless the men are healthy. How are men to be trained so as to start in a campaign in a healthy condition, and to be able to bear the manifold trials of war? The answer may be given under three heads—

1. Preparation for war during peace.
2. Entry on war.
3. Actual service in war.

SECTION I.

PREPARATION FOR WAR DURING PEACE.

The various conditions of war, which are different from those of peace, are—

1. *Exposure to the Weather.*—It is a constant observation that men who have led out-door lives are far more healthy in war than men whose occupations have kept them in houses. The soldier's life should be, therefore, an out-door one. This can only be done properly by keeping him in tents during the summer. It would be well, in fact, to tent the whole army from the middle of May to the end of September every year. The expense

should be looked on as a necessary part of the military establishments. Wooden huts are too like ordinary barracks. As the soldier has often to sleep out in war, he should be accustomed to this also in peace—warm summer nights being first selected to train him. It will soon be found that he will very soon acquire the power of resistance to cold. This plan will also test the utility of his clothes.[1] It has been found by experiment that, by careful training, even delicate persons can bear sleeping out at night, even in tolerably cold weather, without injury, provided there be no rain. At the latter end of the summer, it would be well to expose the men even to rainy nights, their clothes being adapted for this by the supply of waterproofs; and in the very useful Autumn Manœuvres this plan might be tried with advantage.

At the same time, it is important to have the men raised off the ground, both when in tent and lying in the open air, in all countries where the ground may be moist, or cools rapidly during the night. A very useful field hammock has been invented by Captain M'Quire; it consists of a strong woollen material, which is suspended on two sticks by means of guide-ropes. It makes a comfortable bed, and keeps the body very warm.

It may be thought that training of this kind is needless, and that it may be left to the campaign to accustom the men to exposure, but this is not the case; a number of men are rendered inefficient at the commencement of a campaign simply by the unaccustomed exposure.

2. *Tent and Camp Life.*[2]—The pitching, striking, and cleansing of tents; the digging trenches round the tents, and providing for general surface drainage; the arrangement of the interior of the tent, etc., should all be carefully taught. So also the camp life of the campagin should be closely imitated, and the rules of conservancy most strictly carried out as a means simply of teaching what will be of such importance in war.[3]

3. *Cooking of Food.*—No doubt, in future wars all governments will endeavor to supply prepared and cooked food, so as to lessen the cost of transport and the labor of the soldier. But as this cannot always be depended upon, the soldier must be trained to cook his ordinary rations. This should not be done for him; he ought to do it himself merely with the appliances he would have in war, viz., his camp-kettle, canteen, and tin plate.

At the commencement of a campaign many men lose flesh and strength, or suffer from diarrhœa, from the food being badly cooked and indigestible.

In the Peninsular war the men became admirable cooks. At first very large camp-kettles, intended for half a company, were used, and were carried on horses. They did not answer, and the men left them behind. Afterward smaller camp-kettles were supplied, one for each mess of six or eight. Luscombe mentions that the supply of salt was found to be a very

[1] In reference to what was said of the great importance of a hood to the great-coat for men who sleep out at night, an old observation of Donald Monro is of interest. He states that in 1760 the greater health enjoyed by the Austrian Hussars over the other troops was owing to the half-boots, and the large cloaks with hoods carried by these men. (On the Means of Preserving the Health of the Army, 2d edit., 1780, p. 7.)

[2] Reference may be made for fuller details to some excellent treatises on camps published in Germany and Russia, especially by Dr. Roth (Das Zeltlager auf der Lockstädter Heide in Holstein, 1866) and by Dr. Heyfelder (Das Lager auf der Krasnœ-Selo, 1868).

[3] Reference has already been made to the very useful Soldier's Pocket Book, by Sir Garnet (now Lord) Wolseley, which gives full details on all these points.

important point; he says he had no idea of the value of this condiment till he saw the way in which the men saved every little particle; without it, in fact, animal and even vegetable food is unsavory.

In the French army on service 8 or 10 men form a corporal's detachment or *escouade*. They have between them one kettle and cover (*marmite*, weight 1.7 kilog.), one large bowl (*grande gamelle*, weight 1 kilog.), and one large drinking vessel (*grand bidon*, weight 1.5 kilog.) Each man has for his personal use a small bowl (*petite gamelle*) and a small drinking vessel (*petit bidon*). They are all of tinned iron. All these vessels are carried by the men, the larger vessels being taken in turn by the men of the mess.

It may be concluded with regard to this very important matter of cooking utensils, that a man should have a small but very strong canteen, made of unsoldered tin, and with a good deep lid, with a handle which may serve as a frying-pan or second vessel, as well as a cover. The shape of the canteen should be long and flat, and not deeper than is necessary for cooking, so that it may be easily carried. Then all the other vessels, the camp-kettles for each mess, and the large water-vessels, should be carried for the men. They should be made of thin steel, which is very light for its strength, very durable, and is not acted on by the food.

The different kinds of camp cooking to be taught are stewing, boiling, and making soup, making tea and coffee, cooking preserved vegetables, making cakes of flour, and oatmeal porridge.

Reference has already been made to the great importance of not keeping men too long without food. By a little arrangement men can always carry food, and the proper organization of supplies and regimental transport would always enable a commanding officer to have some food for his men. In almost all marches with large bodies of men, and in many actions, there are long periods of inaction during which men could eat food which has been already cooked. The effect of this upon their strength, endurance, and even courage, is remarkable. Some instances have been related by officers in which failures resulted entirely from the exhaustion of the men produced by want of food. Surely it is useless to supply ammunition for guns if the men who are to work have no supply of energy issued also to them.

4. *Water Supply.*—As impure water is a great cause of sickness in war, the soldier should be taught how to recognize impurity, and how to use the simple methods of purification with charcoal, alum, tea, boiling, etc.

5. *Mending Clothes.*—Every soldier carries a hold-all, but many cannot use it properly. It may be suggested whether, in the workshops which are now being established, it would not be well to let every recruit have a month's practice in repairing clothes, and especially boots; simple plans of repair being selected if it be possible.

6. *Cleanliness.*—In war a source of disease is the want of cleanliness. Very soon the person and clothes get covered with lice; all the garments, outer as well as under, get impregnated with sweat, and become very filthy. The best generals have always been very careful on this point, and have had frequent washing parades. As washing clothes is really an art, the soldier should be taught to do it, not by machinery, but in the rude fashion he must practise during war. Clothes can be partially cleaned by drying and beating.

The hair should be cut short. In the absence of water for washing, the best plan is the small-tooth comb, to keep the hair free from vermin.

and it may be a question whether one should not be supplied to every soldier.

Washing the whole body in cold water, whenever it can be done, is not only bracing and invigorating, but strengthens it against vicissitudes of weather, and against dysentery.[1]

SECTION II.

ENTRY ON WAR.

When actual war commences some further steps become necessary.

All experience shows that men under twenty or twenty-one years of age cannot bear the fatigues of war.[2] If possible, then, all men below twenty-one, or at any rate below twenty, should be held back from the campaign, and formed into dépôts, whence they may be drafted for active service on occasion. Of course, every means should be taken during their service at the dépôts to strengthen and harden them.

All weakly men should also be held back, and every man thus retained should come under the surgeon's superintendence, not in hospital, but while doing his duty.

The men who are about to enter on the campaign should at once commence a more severe training. If there be time to do it, this should be carried to an extent even greater than will be demanded in war, in the manner of the Romans, who trained their soldiers so severely in peace that war was a relief. Footsoreness is very common at the commencement of a campaign, and often gives great trouble.

Certain changes in the food of the men should be made.

The exertions of war, bodily and mental, are often very great, and demand an increased quantity of food, especially in the nitrogenous and fatty elements; an increased amount of meat and bread, with the addition of fat bacon, cheese, and peas or beans, should be given, so as to bring the daily amount of nitrogen to 375 or 400 grains, and of carbon to 5,000 grains daily. During the war every effort should be made to get bread and flour supplied in lieu of biscuit, and to supply red wine. As one of the perils of war is the occurrence of scurvy, the supply of fresh vegetables should be increased; if these at all fail during the campaign, the preserved vegetables must be issued, and the other precautions taken. Considering the benefit apparently derived in Captain Cook's voyages from wort made from malt, it might be worth while to try the effect of introducing this as a beverage; it can be readily made.

Donald Monro mentions that at Bremen, in 1762, when no vegetables could be got, and fresh meat was dear, and scurvy broke out, infusion of horse-radish was found to be useful. Spruce beer was also used.

[1] Both Donald Monro and Lind notice this.

[2] The examples are numerous, but the following are often quoted: In 1805 the French army broke up at Boulogne, and marched 400 leagues (French) to fight at Austerlitz; the youngest soldier was twenty-two years old; they left scarcely any sick or wounded *en route*. In 1809 the French marched from the German provinces to Vienna; not half the army were aged twenty years; the hospitals were filled with sick. In 1813 and 1814 the despatches of Napoleon are filled with complaints of the "boys" who were sent him; he said—"I must have grown men; boys serve only to encumber the hospitals and roadsides."

SECTION III.

ACTUAL WAR.[1]

Experience has shown in hundreds of campaigns that there is a large amount of sickness. The almost universality of this proves that, with every care, the conditions of war are unfavorable to health. The strenuous exertions, the broken rest, the exposure to cold and wet, the scanty, ill-cooked, or unwholesome food, the bad water, and the foul and overcrowded camps and tents, account for the amount of disease.

The amount of illness varies with the nature of the campaign and the genius of the commander.

If the records can be trusted, it would seem that the English have been more unhealthy than the French in their wars, but there is no great trust to be placed in war statistics. In the Peninsula the mean daily number of sick was never below 12 per cent. except for a short time, in the lines of Torres Vedras, when it fell to 9 or 10. Sometimes it amounted to 15, 20, or 25 per cent. In the Crimea the immense sickness of the first winter is but too well remembered.

Army Medical Regulations.

Before an army takes the field, the Director-General may appoint a medical officer to act as Field-Inspector under the principal medical officer, but not to act as sanitary officer. The Director-General prepares lists of all medicines, stores, etc. The amount of transport and of stores is laid down.

The Director-General also, on requirement by the War Office, gives an account of everything in the proposed scene of operations which may affect the health of the men. He appoints a sanitary officer to be attached to the Quartermaster-General's department. He issues instructions to the

[1] *Sanitary Rules of the Romans during War.*—Vegetius (De Re Militari, lib. iii., cap. 2) says the Romans took great care that the men should be well supplied with good water, good provisions, firewood, sufficient quantity of wine, vinegar, and salt. They endeavored to keep their armies in good health by due attention—

1. To *situation;* avoiding marshes and dry uncovered ground in summer; in having tents, frequently changing camps in summer and autumn.

2. To the *water;* for bad water was considered to be very productive of diseases.

3. To the *seasons;* not exposing men to heat. In winter, taking particular care that the men never were in want of firewood or of clothing.

4. To *food* and *medicine;* the officers saw that the men had their regular meals, and were well looked after by the commissariat.

5. To *exercise;* by keeping the troops during the day-time in constant exercise; in dry weather in the open air; in time of rain or snow under cover; for exercise was believed to do a great deal more for the preservation of health than the art of physic.

The Præfectus-Castrorum (Quartermaster-General), an officer of high rank in the Roman army, looked after the sick, and provided everything required by the surgeons. Both Livy and Tacitus mention that the commanding officers used to visit the sick and wounded soldiers, to inquire if they were well taken care of. The great health of the Roman soldiers was evidently owing to their great temperance; their excellent warm tents made of hides; their carefully kept camps; the warm war dress or sagum, and their constant exercise.

Rules of the Macedonians.—The only notice of the means by which Alexander the Great preserved so wonderfully the health of his small army seems to be a statement that he frequently changed his encamping grounds (Quintus Curtius, lib. v., 32). This great soldier must certainly have been acquainted with the art of Hygiene.

principal medical officer and sanitary officer on all matters connected with rations, clothing, shelter, precautions for preventing disease, etc.

The sanitary officer inspects all proposed encamping ground, quarters, etc., and supervises the sanitary arrangements of all camps, towns, hospitals, etc. The principal medical officer advises the Commander of the Forces on all matters affecting health, such as rations, shelter, clothing, etc., and may, with the sanction of the Commander of the Forces, issue instructions on such matters to the medical officers.

The sanitary officer inspects the camp daily; accompanies the Quartermaster-General on the march, and gives his advice on all sanitary points. He is supplied with information to aid him in his work from all principal medical officers of general hospitals, divisions, and brigades in the field. He transmits a weekly sanitary report to the principal medical officer.

Causes of Sickness and Mortality in War.

The chief causes of sickness and mortality in the English army have been in order of fatality—

1. Diseases arising from *improper and insufficient food*, viz., general feebleness and increased liability to malarious fevers, dysentery, diarrhœa, etc., and production of scurvy and scorbutic dysentery.
2. *Malarious* disease from unhealthy sites.
3. *Catarrhs*, bronchitis, pleurisy, pneumonia, rheumatism, dysentery (?), produced by inclemencies of weather.
4. *Spotted typhus*, kept up and spread (if not produced) by overcrowding and uncleanliness.
5. *Contagious dysentery*, arising from foul camps and latrines.
6. *Enteric* and perhaps other fevers, produced by foul camps.
7. *Exhaustion and debility*, produced by excessive fatigue—a very great predisposing cause of almost all other diseases.
8. *Cholera*, in India especially.
9. *Yellow fever* in the West Indian and West African campaigns.
10. *Plague* in Egypt.
11. The *exanthemata* occasionally.
12. *Ophthalmia*.
13. *Venereal* diseases.

Of these diseases the most fatal have been scorbutic dysentery and typhus. It is indeed curious to see how invariably in all wars the scorbutic taint occurs, and frequently in how early a period of the campaign it can be detected. There almost seems to be something in the fatigues and anxieties of war which assists its development. It frequently complicates every other disease, impresses on them a peculiar character, and renders them very intractable to treatment. This is the case with dysentery, enteric fever, malarious fever, and spotted typhus. With the last disease, especially, it has intimate relations, and contributes apparently to its propagation by rendering the frame more easily attacked by the specific poison.

One of the most important preventive measures to be adopted in war is the prophylactic treatment of scurvy. But with a full knowledge of this, the disease cannot always be avoided. The Federal Americans were fully aware of the necessity of combating it, and made immense efforts to do so. They did not succeed, and so marked and so general was the scorbutic taint in their army, that its combinations with enteric fever and malaria have been looked upon as new diseases.

If scurvy could be prevented, every other war disease ought to be comparatively trifling. Inflammations from exposure, exhaustion from fatigue, and gastro-intestinal affections from improper food and atmospheric vicissitudes, would still occur; but the ravages of typhus, enteric fever, malaria, and dysentery ought to be trifling, and easily prevented.

To prevent scurvy, then, is one of the most important measures.

If scurvy be absent, typhus fever is readily treated; isolation and the freest ventilation are certain to stop it. The only great danger would be in a besieged and crowded fortress. In such a place it may be beyond control, but early recognition and prompt isolation, as far as it can be done, and as free ventilation as possible, may perhaps stop it. It is in such cases that we should freely use the nitrous acid fumes and other disinfectant vapors.

Enteric (typhoid) fever and contagious dysentery, in the same way, ought with certainty to be prevented in a camp. Recent experience, however, in Affghanistan, South Africa, and Egypt has shown what ravages enteric fever can make, and how rapidly it is generated and spread among troops in campaign. This is certainly due to the neglect of proper hygienic measures. The first case even should make us take urgent measures for the cleansing of latrines, or, better still, the closing of all the old and the opening of fresh ones. But the best plan of all is to shift the encamping ground, and we should remember the old Roman maxim, based doubtless on observation of typhoid fevers, that this must be done more often in the autumn.

The exanthemata, measles, and scarlet fever sometimes spread largely through an army; the only plan is to separate all cases, and send them one day's march on the flank of the army, if it can be done, not in the direction of the line of supplies.

Plague probably demands the same measures as typhus.

The measures for cholera have been already sufficiently noted.

The diseases of exposure can hardly be avoided, but may be lessened by warm clothes and waterproof outer coverings. Flannel should be used next the skin all over the trunk and extremities, and is indispensable. One of the most important means to enable troops to stand inclemencies of weather, and indeed all fatigues, is hot food. Coffee and tea are the best, and hot spirits and water, though useful as an occasional measure, are much inferior, if indeed they do any good at all apart from the warmth. But the supply of *hot* food in war should be carefully attended to, especially in the case of breakfast, after which men will undergo without harm great exposure and fatigue.

It is unnecessary to enter at greater length into the measures to prevent the diseases of war, for the proper plans have been all enumerated previously. We may conclude only that much can be done to prevent disease, but we must also remember that the course of campaigns sometimes is too violent and overpowering for our efforts, and that wars, like revolutions, will never be made with rose-water.

Recapitulation of the Duties of a Sanitary Officer during War.

To go forward with the officers of the Quartermaster-General's department, to choose the camping ground; arrange for surface drainage; if necessarily in a malarious place, make use of all obstacles, as hills, trees, etc., to throw off the malaria from the tents; place the tents with the openings from the malarious quarter. If possible, never take low hills

(100 to 250 feet) above marshy plains. Arrange for the water supply, and for the service of the men, animals, and washing. As soon as possible fix the sites for the latrines; have them dug out, and make dry paths to them. As soon as the tents are pitched visit the whole camp, and see that the external ventilation is not blocked in any way, and that the tents are as far off each other as can be permitted. Assign their work to the scavengers, and mark out the places of deposit for refuse. It is of the greatest importance that all refuse should be immediately and completely destroyed by fire. The destruction of the stools of enteric, dysenteric, and choleraic patients by the same means would probably prove a most important precaution. The daily inspection should include all these points, as well as the inspection of the food and cooking and of the slaughter-houses. If the camp be a large one, a certain portion should be selected every day for the careful inspection of the individual tents, but it should be made in no certain order, that the men may not prepare specially for the inspection.

A set of rules should be drawn up for the men, pointing out the necessity of ventilation, cleanliness of their persons, tents, and ground around them, and ordering the measures which are to be adopted. This will have to be promulgated by the general in command.

In the daily work, a certain order and routine should be followed, so that nothing shall be overlooked.

The sanitary officer of a large camp can never perform his duties without the most unremitting support from the medical officers attached to regiments, who are the sanitary officers of their respective corps. Not only must they inspect their own regimental camps, but by an immediate report to the sanitary officer of any disease which can possibly be traced to some camp impurity, they should render it possible for the commencing evil, of whatever kind, to be detected and checked.

As early as possible every morning the number of men reported sick from each regiment should be made known, and a calculation made of sick to strength, and then, if any regiment showed any excess of sick, the sanitary state of its camp should be specially and thoroughly investigated.

Hospitals in War.[1]

With an army in the field, hospitals are of several kinds.

1. The principal General Hospital at the base of operations.
2. The intermediate Hospitals, divided into—
 - *a.* The Field Hospitals stationed at the base or on the line of communication.
 - *b.* The Field Hospitals proper, which move with the corps, and include the *dressing stations* and *regimental stations.*

The old *regimental hospital* is now definitely abolished, but medical and surgical assistance is provided by a medical officer with one or two attendants, accompanied by bearers, with stretchers when required, as in

[1] Sir James M'Grigor, in the Peninsula, established divisional hospitals in front, and convalescent hospitals in the rear, where the men were received *en route* to the dépôt. Although he does not describe his system fully in his paper in the Medico-Chirurgical Transactions (vol. vi.), it is evident from his Autobiography that his constant practice was to send off the sick as soon as possible. This is shown by his narrative of the retreat from Burgos, when he saved Lord Wellington from the mortification of abandoning his sick and wounded to the enemy. Professor Longmore, in his most instructive work on Transport, has detailed at length the means of transport of the sick and wounded, and other important matters of the kind.

action in the field. The sick are treated in the field hospitals first, and then passed on to the intermediate hospitals in rear, which are again evacuated, as occasion requires, by transfer of patients to the principal general hospital at the base. This last will be in a convenient station on the frontier, or, in case of an insular nation like ourselves, on some sea-coast easily accessible. It is from it that men will ultimately be invalided home if unfit for further service.

For each army corps (of nominally 36,000 men) 25 field hospitals are appointed—12 to move with the corps, and 13 to be stationed at the base and along the lines of commnnication[1]—each is equipped for 200 sick, and may be divided into half hospitals for 100 each, if necessary. Slight cases would be treated in the field hospitals, but all cases likely to take any time should be sent to the rear of operations as soon as possible. Cases of fever (typhus and enteric) ought to be removed as soon as possible far from the field force. It is of great importance that they should not be put near surgical cases, which ought to be kept separate, or mixed only with non-communicable diseases. This (the separation of fever from surgical cases) was a Peninsular rule of Sir James M'Grigor, and should never be forgotten. Ophthalmic cases ought also to be isolated.

The hospitals in rear may be at some distance, but connected either with a railway or by water carriage. It is of great importance to keep continually sending patients from the division and general hospitals with the army to the hospitals in rear. It is not only to keep the hospitals in front empty for emergencies, and to facilitate all movements of the army, but it has a great effect on the army itself. A great hospital full of sick is a disheartening spectacle, and often damps the spirits of the bravest men. The whole army is higher in hope and spirits when the sick are removed, as was shown remarkably by the Austrian experience of 1859. The sick themselves are greatly benefited by the removal; the change of scene, of air, of ideas, has itself a marvellous effect, and this is another great reason for constantly evacuating the sick from the hospitals in front.

The men who are reported for hospital in war must be divided into several classes—

1. Slightly wounded should be treated in the field or intermediate hospitals, and then returned to duty.
2. Severely wounded at first in the field hospitals, then sent to the intermediate hospital, and then to the rear, as convalescence is always long.
3. Slight colds, diarrhœa, etc., treated in the field hospitals.
4. Severer colds, bronchitis, pleurisy, pneumonia, dysentery, etc., should be sent at once to the intermediate hospital, and then to the rear as soon as they can move with safety.
5. Typhus fever at once to the hospitals in rear, if possible without entering the field hospitals.
6. Enteric cases, also, should be sent to the rear, and, in fact, all severe cases. The field hospitals should be always almost empty, and ready for emergencies.

These hospitals in rear may be even two or three days' journey off, if conveyance be by water, or one or two days if by rail. Sick and wounded men bear movement wonderfully well, with proper appliances, and are often indeed benefited.[2]

[1] For full details of the new hospital organization in the field, see Professor Longmore's work, Gunshot Injuries (1877), sec. ix., chap. 1.

[2] On this and other points of the like kind, see Report on Hygiene, in the Army Medical Report for 1862, pp. 349, 350.

The proper position for the hospitals at the base of operations must be fixed by the commander of the forces at the commencement of the campaign, as he alone will know what point will be the base of supplies, and it is of importance to have these great hospitals near the large stores which are collected for the campaign.

It seems now quite clear that these hospitals should not be the ordinary buildings of the country adapted as hospitals. Such a measure seldom succeeds, and the mere adaptation is expensive, though probably always imperfect.[1] Churches should never be taken, as they are not only cold, but often damp, and there are often exhalations from vaults.

The French, Austrian, and American experience is in favor of having the hospitals in rear made of tents or wooden huts. The huts are perhaps the best, especially if the winter be cold. They were very largely used by the Federal Americans, who gave up entirely converting old buildings into hospitals. The best huts which were used in the Russian war of 1854–56 were those erected at Renkioi from Mr. Brunel's design; each held fifty men in four rows. This plan, however, is not so good a one as having only two rows of beds. Hammond[2] states that in the American war the best size has been found to be a ward for fifty men with two rows of beds; length of ward, 175 feet; width, 25; height, 14 feet; superficial area per man, 87 feet; cubic space per man, 1,200 feet. Ventilation was by the ridge, an opening 10 inches wide, running the whole length, and by openings below, which could be more or less closed by sliding doors. Some of the American hospitals held from 2,000 to 2,800 beds.[3] It is probable, however, that smaller wards (for 25 men) would be better.

An hospital constructed of such huts can be of any size, but there must be several kitchens and laundries if it be very large. If space permit, however, it seems desirable to have rather a collection of smaller hospitals of 500 beds each, separated by half a mile of distance, than one large hospital.

The arrangement of the huts must be made according to the principles already laid down. Dr. Hammond writes thus of these hospitals:—

"It will, perhaps, not be out of place again to insist on the great advantages of these temporary field hospitals over those located in permanent buildings in towns. Nothing is better for the sick and wounded, winter and summer, than a tent or a ridge-ventilated hut. The experience gained during the present war establishes this point beyond the possibility of a doubt. Cases of erysipelas or of hospital gangrene occurring in the old buildings, which were at one time unavoidably used as hospitals, but which are now almost displaced for the ridge-ventilated pavilions, immediately commenced to get well as soon as removed to the tents. But in one instance that has come to my knowledge has hospital gangrene originated in a wooden pavilion hospital, and in no instance, as far as I am aware, in a tent. Hospital gangrene has been exceedingly rare in all our hospitals, but two or three hundred cases occurring among the many wounded, amounting to over 100,000 of the loyal and rebel troops, which have been treated in them. Again, wounds heal more rapidly in them, for the reason that the

[1] Donald Monro says that, in 1769, the houses in Germany taken for the sick were improved by taking away the stoves and putting in open fire-places. In the Peninsula, the Duke of Wellington appeared to have a dread of fever attacking the army. Luscombe tells us that the Duke asked the principal medical officer every day as to the appearance of fever. He also improved the hospitals by ordering open fire-places.—Luscombe, p. 6.

[2] On Hygiene, p. 355.

[3] See Report on Hygiene, in the Army Medical Report for 1862, p. 345 et seq., for a fuller description.

full benefit of the fresh air and the light are obtained. Even in fractures the beneficial effects are to be remarked."[1]

Baron Larrey, in his useful work,[2] describes the plans adopted by the French in the Italian war of 1859. At Constantinople, during the Crimean war, the French were apparently very well installed; the best buildings in Constantinople were assigned to them, and they were arranged with all the accuracy of organization which distinguishes the French. The results were not, however, favorable, especially in the spring of 1856, when typhus spread through many of the hospitals, and caused great mortality.[3] Taught by this experience, in the Italian war of 1859 the French distributed their sick in small hospitals whenever they could find a building, and in this way the extension of the specific diseases was entirely stopped.

In the great Franco-Prussian war of 1870–71, the Germans made great use of temporary hospitals, and distributed their sick and wounded over almost the whole of Germany. The plans were very similar to those used in the Crimean and American wars. In some of the large cities, as at Berlin, immense hospitals, with railways and every appliance, were fitted up. The experience as regards hospital gangrene and erysipelas was favorable, but there were many cases of pyæmia in some of these hospitals.

To sum up, the hygiene of field hospitals in war (the rules are derived from our own Crimean experience, and that of the wars which have taken place since) is as follows:—The field, including the intermediate, hospitals to be made of tents; the tents being well constructed, of good size, thoroughly ventilated, the flaps being able to be raised so as almost, if desired, to make the tent into an awning. The most convenient and best are the hospital marquees of the new pattern, except for their considerable weight. The new double circular tents will now be used in all probability: they are a great improvement on the old bell-tent, and lighter than the marquee. Each weighs 100 lb dry, and four patients are put in a tent. For operating purposes, the central pole can be removed and a tripod support substituted, so as to leave the centre free.

The ground round the tents to be thoroughly drained, kept very clean, and replaced from time to time. The tent floor to be covered with clean, and, if possible, *dried* earth, or charcoal, and to be then covered with a waterproof cloth, or boarded, if the camp be one of position. In either case the greatest care must be taken that the ground does not get soaked and filthy. Every now and then (if possible every ten days or so) the tents should be shifted a little.

If it can be done, the sick should be raised off the ground. Iron bedsteads are cumbrous, but small iron pegs stuck in the ground might carry a sort of cot or hammock. The advantage of a plan of this kind is that by means of holes in the sacking wounded men can have the close-stool without much movement. For fever cases it permits a free movement of air under the patient.

[1] On Hygiene, p. 397. [2] Notice sur l'Hygiène des Hôpitaux Militaires, 1862.

[3] Larrey mentions some striking instances of the effects of overcrowding. At Rami-Tchifflick, the hospital was fixed for 900 by the surgeon in charge, who allowed no more; it remained healthy. His successor increased the beds to 1,200 and then to 1,400. Typhus became most severe, and spared no one (*ni infirmiers, ni sœurs, ni médecins*). In the hospital at Pera there was the same mistake and the same results. Typhus caused 50 per cent. of the deaths. At the hospital of the École Militaire no crowding was permitted, and typhus caused only 10 per cent. of the deaths. In the French ambulances in the Crimea the same facts were noticed. Double and treble numbers were crowded into some, and they were ravaged by typhus; others were not allowed to be crowded, and had little typhus.

The stationary general hospitals in rear should be of tents or wooden huts, but never of converted buildings, or of hospitals used by other nations. Here, of course, iron bedsteads, and all the appurtenances of a regular hospital, are brought into play.

Whenever practicable, the rear hospital should have water-closets and sewers. At Renkioi, in Turkey, Mr. Brunel supplied square wooden sewers about fifteen inches to the side; they were tarred inside, and acted most admirably, without leakage, for fifteen months, till the end of the war. The water-closets (Jenning's simple siphon), arranged with a small water-box below the cistern to economize water, never got out of order, and, in fact, the drainage of the hospital was literally perfect. Dr. Parkes had little doubt such well-tarred wooden sewers would last two or three years.

There is one danger about wooden hospitals, viz., that of fire. The huts should, therefore, on this ground alone, be widely separated; each hut should have, about ten feet from it, an iron box for refuse. Wooden boxes do not answer, as in the winter live cinders get thrown in, and there is danger of fire. These boxes should be emptied every morning by the scavengers, and the contents burned as soon as possible. Water must be laid on into every ward.

The arrangement of the buildings is a simple matter, but must partly be determined by the ground. Long open lines are the best. An hospital of this kind, completely prepared in England, can be put up at a very rapid rate,[1] supposing there be no great amount of earth-work, and that the supply of water and of outlet for sewage be convenient. So that, if commenced at once at the beginning of a campaign, accommodation would soon be provided.

Circumstances may of course render it necessary to take existing buildings for hospital purposes, but it ought always to be remembered that it is running a very great risk, and nothing but rigid necessity ought to sanction it.

Laundry Establishment.

This part of an hospital must be organized as early and as perfectly as possible. The different parts must be sent out from England, viz., boiler, drying-closet, washing-machines, and wringing-machines. The washing in war can never be properly done by the people among whom the war is carried on. Every appliance to save labor must be used, and after calculating what amount of laundry work has to be done for a presumed number of sick, just twice the amount of apparatus should be sent out, partly to insure against breakage, partly to meet moments of great pressure. The drying-closet, especially, is a most important part of the laundry, as its heat can be used to disinfect.

[1] The hospital at Renkioi, in Turkey, in the Crimean war, was made of such large huts (50 men in each) that its rapidity of erection is no guide to others; yet it was marvellously soon put up. The first beam was laid on May 24, 1855; on July 12th it was reported ready for 300 sick, every ward having water laid on, baths and closets, and an iron kitchen and laundry being also ready; on August 11th it was ready for 500, and on December 4th for 1,000 sick. In January, 1856, it was ready for 1,500 sick, and in a short time more 2,200 could have been received. The number of English artisans was only forty, but we had native workmen, and if we had had eighty English artisans it would have been ready for 1,000 sick in three months. Smaller huts could be put up in much less time if the ground requires no terracing.

Amount of Hospital Accommodation.

This must not be less than for 25 per cent. of the force, with reserve tents in rear in case of need.

Cemeteries in war must be as far removed as possible ; the graves dug deep, and peat charcoal thrown in if it can be procured. Lime is generally used instead, but is not quite so good. If charcoal cannot be got, lime must be used. If the army is warring on the sea-coast, burial in the sea might be employed. But cremation would be best, and forms of ambulatory furnaces have been proposed.

Sanitary Duties connected with a War Hospital.

In addition to the usual sanitary duties of an hospital, there are one or two points which require particular attention in the field.

The first of these is the possible conveyance of disease by the exceedingly dirty clothes, which may perhaps have been worn for weeks even without removal, in the hard times of war. Typhus, especially, can be carried in this way.

To provide for this, every hospital should have a tent or building for the reception of the clothes ; here they should be sorted, freely exposed to air, and the dirty flannels or other filthy clothes picked out. Some of these are so bad that they should at once be burnt, and the principal medical officer, at the beginning of a campaign, should have authority given him to do this, and to replace the articles from the public store.

The articles which are not so bad should be cleansed. The cleansing is best done in the following way :—If the hospital have a laundry and drying-closet, they should be put first in the drying-closet for an hour, and the heat carried to 220° Fahr. Then they should be transferred into the fumigation box ; this is simply a tin-lined box or large chest. The clothes are put in this, and sulphur placed above them is set on fire, care being taken not to burn the clothes ; or nitrous acid fumes should be used. After an hour's detention in the fumigating box, they should be removed to the soaking tubs. These are large tubs with pure water, put in a shed or tent outside the laundry. A little chloride of lime can be added to the water. They should soak here for twenty-four hours, and then go into the laundry and be washed as usual. This plan, and especially the heating and fumigation, will also kill lice, which often swarm in such numbers.

Another point of importance is to bathe the men as soon as possible. The baths of a war hospital at the base of operations should be on a large scale, and the means for getting hot water equally large. The men's heads, if lousy, should be washed with a little weak carbolic acid, which kills the lice at once. The smell is not agreeable, but that is not of real consequence.

In a war hospital, also, the use of charcoal in the wards, antiseptic dressings, the employment of disinfectants of all kinds, is more necessary than in a common hospital.

As a matter of diet, there should be a large use in the diet of antiscorbutic food, vegetables, etc., and antiscorbutic drinks should be in every ward, to be taken *ad libitum*—citric acid and sugar, cream of tartar, etc. The bread must be very good, and of the finest flour, for the dysenteric cases.

Sieges.

The sanitary duties during sieges are often difficult. Water is often scarce, disposal of sewage not easy, and the usual modes of disposal of the dead cannot, perhaps, be made use of. If sewage is not washed away, and if there is no convenient plan of removing it by hand, it must be burnt. Mixing it with gunpowder may be adopted if there is no straw or other combustible material to put with it.

If food threaten to run short, the medical officer should remember how easily Dr. Morgan's process of salting meat can be applied, and in this way cattle or horses which are killed for want of forage, or are shot in action, can be preserved. For sieges, as vegetables are sure to fall short, a very ample supply of lemon-juice and of citric acid, citrates, and cream of tartar should be laid in and distributed largely.

One other point should be brought to the notice of the general in command. In times of pressure, every man who can be discharged from the hospital is sent to the front. This cannot always be avoided. But when there is less pressure, the men should go from the rear hospitals to a dépôt, and while there should still be considered under medical treatment, so that they may not too soon be subjected to the hardships of war. They should, in fact, be subjected again to a sort of training, as if they were just entering on the war. If this is not done, a number of sickly or half-cured men get into the ranks, who may break down in a moment of emergency, and cause great difficulty to the general in command. Some officers think that a man should either be in hospital or at his full duty; this seems a misapprehension both of the facts and of the best way of meeting them. To transfer a man just cured, from the comforts of a hospital at once to the front, is to run great danger. A dépôt, which should be a sort of convalescent hospital, though not under that term, is the proper place to thoroughly strengthen the man just recovered for the arduous work before him.

APPENDIX A.

STANDARD SOLUTIONS FOR VOLUMETRIC ANALYSIS.

1. *For Chlorine.*

(*a*) *Silver Nitrate Solution.*

4.788 grammes of silver nitrate in 1 litre of distilled water.
1 CC. of solution = 1.00 milligramme of chlorine.
" " = 1.51 " of ammonium chloride.
" " = 1.65 " of sodium chloride.
" " = 2.10 milligrammes of potassium chloride.

This solution may be *standardized* with a solution of pure sodium chloride, 1.648 to the litre, 1 CC. of which equals 1 mgm. of chlorine.

(*b*) *Potassium Monochromate Solution.*—50 grammes of potassium monochromate are dissolved in one litre of distilled water. Solution of nitrate of silver is added until a permanent red precipitate is formed, which is allowed to settle.

2. *Hardness.*

(*a*) *Soap Solution.*

Dissolve some soft soap (pharmacopœial) in diluted spirit, and graduate by means of this barytic solution.

Nitrate of barium 0.26 gramme.
Distilled water 1 litre.

2.2 CC.s (or 22 *measures*) of standard soap solution produce a permanent lather with 50 CC.s of the the above solution.

1 measure ($= \frac{1}{10}$ CC.) of soap solution = 0.00025 gm. = 0.25 mgm. of calcium carbonate.

Correction for lather = − 2 measures of soap.

Short factors (when 50 CC.s of water are taken for experiment).

For degrees of Clark's scale (1 : 70,000) = 0.35.
" " Metrical " (1 : 100,000) = 0.50.

(*b*) A weaker solution, each measure ($\frac{1}{10}$ CC.) of which is equal to 0.07 mgm. of $CaCO_3$ is sometimes used. The correction for lather would be 7 measures of soap. The corrected number of measures, divided by 10, gives the hardness in Clark's scale directly, or multiplied by 0.14 the degrees on the metrical scale.

3. *Solutions required for the determination of Oxidizable Matter in Water.*

(*a*) *Permanganate Solution.*

0.395 of potassium permanganate in 1 litre of water.

100 CC.s are exactly decolorized by 100 CC.s of *oxalic acid solution* (*c*). (*See* No. 7.)

1 CC. of permanganate solution used with acid yields 0.10 milligramme of oxygen.

1 CC. of permanganate solution used with alkali yields 0.06 milligramme of oxygen.

1 CC. of permanganate solution exactly oxidizes 0.2875 mgm. nitrous acid (NO_2).

1 CC. of permanganate solution exactly oxidizes 0.2125 mgm. hydrogen sulphide (H_2S).

1 CC. of permanganate solution exactly oxidizes 0.7000 mgm. iron (Fe).
" " " " 0.9000 " ferrous oxide (FeO).

(*b*) *Potassium Iodide Solution.*—A 10 per cent. solution of the pure potassium iodide, recrystallized from alcohol.

(*c*) *Dilute Sulphuric Acid.*—One *volume* of pure sulphuric acid is mixed with three *volumes* of distilled water, and permanganate solution dropped in until the whole retains a *very faint* pink tint, after warming to 80° F. for four hours.

(*d*) *Sodium Hyposulphite.*—One gramme of crystallized sodium hyposulphite dissolved in 1 litre of water.

(*e*) *Starch Solution.*—One gramme of starch to be intimately mixed with ½ litre of distilled water, the whole boiled briskly for five minutes, filtered, and allowed to settle.

4. *Solutions for determination of Free and Albuminoid Ammonia.*

(*a*) *Ammonium Chloride Solution for Nesslerizing.*

0.315 gramme of ammonium chloride in 1 litre of water.
This is the *strong* solution.

Take 100 CC.s of this solution and dilute to 1 litre.
This is the *standard* solution.

1 CC. = 0.01 milligramme of ammonia (NH_3) or 0.0082 mgm. of nitrogen.

(*b*) *Nessler's Solution.*—Dissolve 35 grammes of potassium iodide in 100 CC.s of distilled water. Dissolve 17 grammes of mercuric chloride in 300 CC.s of distilled water; warm if necessary, and allow to cool. Add the mercuric solution to the iodide solution until a perceptible permanent precipitate is produced. Then dilute with a 20 per cent. sodium hydrate solution (caustic soda) up to 1,000 CC.s (1 litre): add mercuric chloride solution until a permanent precipitate again forms; allow precipitate to settle, and then decant off the clear solution.

(*c*) *Sodium Carbonate* (sometimes required for free ammonia, but not usually needed).—A 20 per cent. solution of recently ignited pure sodium carbonate.

(*d*) *Alkaline Potassium Permanganate Solution* (for Albuminoid Ammonia).—Dissolve 200 grammes of potassium hydrate and 8 grammes of pure potassium permanganate in 1,100 CC.s of distilled water, and boil the solution rapidly till concentrated to 1,000 CC.s.

(*e*) *Distilled Water free from Ammonia.*—The S. P. A. recommend boiling ordinary distilled water with 1 per 1,000 of pure ignited sodium carbonate. If the water is distilled with a little phosphoric acid (as recommended by Notter), it comes over quite free. Test with a little Nessler's solution.

5. *Re-agents for the determination of Nitric Acid in Nitrates.*

(*a*) *Metallic Aluminum.*—As thin foil.

(*b*) *Solution of Sodium Hydrate.*—Dissolve 100 grammes of solid sodium hydrate in 1 litre of distilled water. When cold, introduce a strip of about 100 square centimetres, say 15 square inches, of aluminum foil, previously heated to just short of redness, wrapped round a glass rod; when the aluminum is dissolved, boil the solution briskly in a porcelain basin until about one-third of its volume has evaporated; allow it to cool, and make it up to its original volume with water free from ammonia. The solution must be tested by a blank experiment to prove the absence of nitrates.

(*c*) *Copper Sulphate Solution.*—Dissolve 30 grammes of pure copper sulphate in 1 litre of distilled water.

(*d*) *Metallic Zinc, pure.*—As thin foil. This should be kept in a dry atmosphere, so as to be preserved as far as possible from oxidation.

To make the *wet Copper Zinc copple.*—Put into a flask or bottle a piece of clean zinc foil, and cover it with the copper solution (*c*): allow the foil to remain until it is well covered with a firmly adhering black deposit of copper. (If left too long the deposit may peel off in washing.) Pour off the solution (which may be kept for further use), and wash the conjoined metals with distilled water. The copple is now ready for use. About one square decimetre ($=\frac{1}{9}$ of a square inch) should be used for every 200 CC.s of a water containing 5 parts or under of nitric acid in 100,000. For waters richer in nitrates more will be required.

(*e*) *Standard Solution of Ammonium Chloride* (*see* 4 (*a*)).

(*f*) *Nessler's Solution* (*see* 4 (*b*)).

6. *Re-agents for the determination of Nitrous Acid in Nitrites.*

(*a*) *Solution of Metaphenylenediamine.*—Dissolve 5 grammes of metaphenylenediamine in 1 litre of distilled water, rendered acid with sulphuric acid. Decolorize, if necessary, with animal charcoal.

(*b*) *Dilute Sulphuric Acid.*—One volume of pure sulphuric acid to two volumes of distilled water.

(*c*) *Solution of Potassic Nitrite.*—Dissolve 0.406 gramme of pure silver nitrite in hot water, and decompose it with a slight excess of potassium chloride. After cooling, make the solution up to one litre, allow the chloride of silver to settle, and dilute each 100 CC.s of the clear supernatant liquid again to one litre. 1 CC. of this diluted solution = 0.01 of a milligramme of NO_2.

The nitrites may also be determined by the permanganate solution (*see* 3).

7. *For determination of Phosphoric Acid.*

One part of pure molybdic acid is dissolved in 4 parts of ammonia, sp. gr. 0.960. This solution, after filtration, is poured, with constant stirring, into 15 parts of nitric acid of 1.20 sp. gr. It should be kept in the dark, and carefully decanted from any precipitate that may form.

8. *Sulphuric Acid Solution for Carbonates in Water.*

Take 4.9 grammes *by weight* of pure H_2SO_4 and dilute to 1 litre.
1 CC. saturates 5 milligrammes of calcium carbonate.
" " 6.2 " of sodium "

9. *Alkaline Solution for Acidities.*

Take liquor sodæ or liquor potassæ of pharmacopœial strength, and dilute with 8 or 9 parts of distilled water.
Graduate with *oxalic acid solution* (*a*). (*See* No. 7.)

1 CC. of standard alkaline solution = 6.3 mgm. oxalic acid.
= 6 " glacial acetic acid.
= 9 " lactic acid.
= 7.5 " tartaric "
= 6.4 " citric "

10. *Oxalic Acid Solutions.*

Solution (*a*)—Take 6.3 grammes of crystallized oxalic acid, and dissolve in one litre of water.

10 CC.s exactly neutralize 10 CC.s of standard alkaline solution.

Solution (*b*)—Take 100 CC.s of *solution* (*a*) and add 180 CC.s of distilled water; or, dissolve 2.25 grammes of crystallized oxalic acid in one litre of distilled water.

This makes the solution for testing the alkalinity of lime or baryta water.

1 CC. exactly neutralizes 1 milligramme of lime (CaO.)
" " " 2.73 " of baryta BaO.

Solution (*c*)—Take 100 CC.s of *solution* (*a*) and add 700 CC.s of distilled water; or, dissolve 0.7875 gramme of crystallized oxalic acid in one litre of distilled water.

This is the solution for graduating the permanganate.

100 CC.s exactly decolorize 100 CC.s of permanganate in presence of sulphuric acid.

11. *Copper Solution* (*Fehling's*) *for Sugars.*

Take of pure copper sulphate 34.64 grammes. } *Dissolve.*
" distilled water 200 CC.s. }
Take also of tartrate of sodium and potassium, 173 grammes. } *Dissolve.*
Solution of caustic soda (or caustic potash) .. 480 CC.s. }
Mix the two solutions slowly, and dilute with distilled water to one litre.
1 CC. is reduced by 5 milligrammes of either glucose or inverted sugar.
1 CC. " 6.67 " of lactin (or milk sugar).

12. *Iodine Solution for Hydrogen Sulphide.*

Dissolve 6.35 grammes of iodine in 1 litre of distilled water by the aid of a little potassium iodide.

1 CC. = 0.85 milligramme of H_2S.

If a litre of water be taken for examination, the short factor for cubic inches per gallon is 0.164.

Starch is used as the indicator.

13. *Solution of Iron for Colorimetric Test.*

Dissolve one gramme of pure iron wire in nitro-hydrochloric acid; precipitate the ferric oxide with ammonia; wash the precipitate; dissolve in a little hydrochloric acid, and dilute to 1 litre.

1 CC. = 1 milligramme of iron.

This is the strong solution.

For use it is diluted 1 to 100, so that

1 CC. = 0.01 milligramme of metallic iron.
1 CC. = 0.027 " of iron phosphate.

14. *Dilute Acid Solutions* are generally 1 part of acid to 9 of distilled water, unless otherwise specified.

15. *Qualitative Solutions*, and, generally, solutions that are not titrated or graduated, are *saturated*, unless otherwise specified.

16. *Brucine Solution* (for *Nitric Acid*).—1 gramme of brucine to 1 litre of distilled water.

17. *Solution of Potassium Iodide and Starch* (for *Nitrous Acid*).

Potassium iodide 1 gramme, starch 20 grammes, water 500 CC.s. Make the starch, filter when cold, and then add the potassium iodide.

This mixture does not keep well, and must be made fresh from time to time; or, the solutions 3 (*b*) and 3 (*e*) may be used instead.

18. *Solution of Gold Chloride* (for *Oxidizable Matter* in Water).—One gramme of gold chloride dissolved in 1 litre of water.

19. *Solution of Cochineal* (for *Acidities* or *Alkalinities*).—Take 5 grammes of cochineal, bruised in a mortar, add 25 CC.s of spirit of wine and 500 CC.s of distilled water; filter. This solution is apt to become a little acid.

20. *Phenol-Phthaleine Solution* (for *Acidities* or *Alkalinities*).—Take 5 grammes of the phenol-phthaleine, and dissolve, with the aid of 25 CC.s of spirit of wine, in 500 CC.s of distilled water.

21. *Use of Sikes' Hygrometer*, for ascertaining the strength of spirits.

A sample of the spirits to be tested is poured into a trial glass, and the temperature ascertained by means of a thermometer in the usual way. The hydrometer is taken, and one of the weights is attached to the stem below the ball; it is then pressed down to the 0 on the stem. If the right weight has been selected it will float up to one of the divisions on the stem. The number on the *stem* is then read off and added to the number on the *weight*; the sum is called the *indication*. The book of tables is then opened at the temperature first found, and the indication looked for in one of the columns; opposite it will be found the strength of the spirits *over* or *under*

proof. If at the temperature 60° F. the *indication* is 58.8, then opposite this will be found zero, that is, the spirit is the exact strength of *proof*. If the indication is 50, then opposite that is 12.8, or the spirit is 12.8 *over* proof; if the indication is 70, then opposite is 18.9, or the spirit is 18.9 *under* proof. The meaning of these expressions is—(1) If the spirit be 12.8 over proof, then, in order to reduce it to proof, 12.8 gallons of water must be added to 100 gallons of the spirit; the resulting mixture will be proof; (2) if the spirit be 18.9 under proof, this means that 100 gallons contain only as much alcohol as 89.1 (*i.e.*, 100–18.9) of proof spirit; to raise it to proof it would have to be mixed with an equal quantity of spirit as much above proof as it is below it, so that $\frac{100-18.9+118.9}{2} = 100.$

The "Adulteration of Food and Drugs Amendment Act," 1879, allows brandy, whiskey, or rum to be 25 degrees under proof; equal to 42.6 per cent. of absolute alcohol, volume in volume, or 34.1 per cent. of weight in volume. This gives a specific gravity of .947. Gin is allowed to be 35 degrees under proof, equal to 36.9 per cent. volume in volume, or 29.5 per cent. weight in volume of absolute alcohol. This gives a specific gravity of .956. Proof spirit contains 56.8 volume in volume, or 45.4 weight in volume of absolute alcohol, sp. gr. .920. The presence of sugar or extractives renders the use of the hydrometer fallacious unless the spirit is distilled off.

APPENDIX B.

METRICAL WEIGHTS AND MEASURES.

a. Length.

1 Metre	= 39.37	English inches	= 3.28 feet.	
1 Decimetre	= 3.94	"	"	= (4 inches nearly).
1 Centimetre	= 0.39	"	"	= ($\frac{4}{10}$ inch nearly).
1 Millimetre	= 0.039	"	"	= ($\frac{1}{25}$ inch nearly).

N.B.—The *Latin* prefix indicates division.
The *Greek* " " multiplication.

1 Kilometre = 1,000 metres = 1,094 yards = $\frac{5}{8}$th mile (nearly).
1 Mile (English) = 1,609 metres, or 1.609 kilometre.

b. Area.

1 Square Metre	= 10.76	sq. feet	= 1,542 sq. inches.
1 Square Centimetre	= 0.154	sq. inch	= $\frac{2}{13}$ sq. inch (nearly).
1 Square Millimetre	= 0.0015	"	= $\frac{1}{650}$ " (nearly).
100 Square Metres	= 1 are	= 119.7	square yards.
100 Ares	= 1 hectare	= 11967.0	" = 2.47 acres.
100 Hectares	= 1 square kilometre	= 247	acres = 0.386 sq. mile.

c. Capacity.

1 Decimetre cubed = 1 litre = 1,000 cubic centimetres = 61 cubic inches = 35.3 ounces = 0.22 gallon.
1 Cubic centimetre = 0.061 cubic inch.
1 Cubic inch = 16.4 cubic centimetres.
28.35 Cubic centimetres = 1.733 cubic inch = 1 ounce.
1,000,000 Cubic centimetres = 1,000 litres = 1 cubic metre = 1 stere = 35.3 cubic feet.

d. Weight.

1 Cubic centimetre of distilled water at 4° C. (39.2° F.) weighs 1 gramme.
1 Gramme = 15.432 grains.
1 Decigramme = 1.543 grain (= 1½ grain nearly).
1 Centigramme = 0.154 " (= $\frac{3}{13}$ grain nearly).
1 Milligramme = 0.015 " (= $\frac{1}{25}$ grain nearly).
1 Kilogramme = 1,000 grammes = 15,432 grains = 2.2 lb *avoir.* = 35.3 ounces.
French *livre* and German *pfund* = 500 grammes = 1.1 lb = 17.6 ounces.
The German *loth* = 16⅔ " = ⅝ ounce nearly.
1 lb *avoir.* = 453.5 grammes.
1 ton *avoir.* = 1,018 kilogrammes.

APPENDIX C.

THERMOMETER SCALES.

$$\frac{\text{Centigrade}}{5} = \frac{\text{Réaumur}}{4} = \frac{\text{Fahrenheit}-32}{9}$$

	Centigrade.	Réaumur.	Fahrenheit.
Mercury freezes at	−40.0°	−32.0°	−40.0°
Zero of Fahrenheit	−17.7	−14.2	0.0
Water freezes at	0.0	0.0	32.0
Water at its maximum density at	4.0	3.2	39.2
Mean temperature of London	10.2	8.2	50.4
Mean temperature for specific gravities, etc.	15.5	12.4	60.0
Mean temperature of Calcutta	25.8	20.6	82.0
Mean temperature of the human body	38.5	30.0	98.4
Alcohol boils at	78.3	62.7	173.0
Water boils at	100.0	80.0	212.0
Mercury boils at	360.0	288.0	680.0

APPENDIX D.

BAROMETER SCALES.

Standard pressure	= 760	millimetres = 29.922	inches.
30 inches	= 762	"	
29.5 "	= 749	"	
29 "	= 737	"	
28.5 "	= 724	"	
28 "	= 711	"	
1 inch	= 25.4	"	

APPENDIX E.

1. *Table showing the daily yield of Water from a Roof with varying Rainfalls.*[1]

Area of House, 10 by 20 feet, or 200 square feet.

Mean Rainfall.	Loss from Evaporation.	Requisite capacity of Tank.	Mean daily yield of Water.	Mean daily yield of Water in wettest year.	Mean daily yield of Water in driest year.
Inches.	Per cent.	Cubic feet.	Gallons.	Gallons.	Gallons.
20	25	100	4.3	6.7	3.2
25	20	135	5.7	7.5	3.9
30	20	145	6.8	9.4	4.5
35	20	155	7.9	11.0	5.0
40	15	165	9.7	13.1	7.2
45	15	170	10.9	14.2	8.6

For any other size of roof or amount of rainfall, the numbers will be proportional.

2. *Tables showing the Distribution of* Positive *and* Negative *Errors, according to Number of Events.*

(*a*) 1 Event.

Chances.	
1 positive	1
1 negative	1
Total	2

(*b*) 2 Events.

Chances.	
2 positive	1
1 positive, 1 negative	2
2 negative	1
Total	4

[1] From a paper by H. Sowerby-Wallis, F.M.S., on Rainfall Collection, Transactions of the Sanitary Institute of Great Britain, vol. i., 1880 (Croydon Congress), p. 213.

(*c*) 3 Events.

	Chances.
3 positive	1
2 positive, 1 negative	3
1 positive, 2 negative	3
3 negative	1
Total	8

(*d*) 4 Events.

	Chances.
4 positive	1
3 positive, 1 negative	4
2 positive, 2 negative	6
1 positive, 3 negative	4
4 negative	1
Total	16

(*e*) 10 Events.

	Chances.
10 positive	1
9 positive, 1 negative	10
8 positive, 2 negative	45
7 positive, 3 negative	120
6 positive, 4 negative	210
5 positive, 5 negative	252
Carry forward	638
Brought forward	638
4 positive, 6 negative	210
3 positive, 7 negative	120
2 positive, 8 negative	45
1 positive, 9 negative	10
10 negative	1
Total	1,024

In each case the number of chances correspond to the coefficients of a binomial whose exponent is the number of events. Thus, with 1 event we have $(a+b)^1 = a+b$; with 2 events we have $(a+b)^2 = a^2+2ab+b^2$, and so on.

AMERICAN APPENDIX

TO

PARKES' HYGIENE.

INTRODUCTION.

THE fundamental principles of hygiene underlying all measures aimed at the improvement of the health of mankind so carefully brought out in the preceding pages are, of course, applicable to all countries, climates, and habits of living; but there is very much that is of a practical nature, applicable to England and English ways which it would be impossible to follow in the United States, where existing conditions of climate, government, density, and movement of population are so totally different. For this reason it has been thought best to supplement the theoretical part of the treatise bearing Dr. Parkes' name by a short sketch of American practice in matters relating to public health, and the progress that has been made in sanitary science during the last few years.

Although for many years a department for the study of subjects relating to State medicine, and for the employment of such methods as would tend to improve the health of the nation, has had its place in the internal policy of England, it was not till the year 1869 that any measures looking to the same results were inaugurated in America. In that year Massachusetts created a State board of health, and gradually other States have followed her example till twenty-nine now have their departments of health.

The creation of these boards of health has been the outcome of a gradually growing public recognition of the need for concerted action in the prevention of disease, a feeling that received great impetus during the epidemic of 1878. Much of this interest is, however, due to the fact that it can now be proved that a large proportion of the deaths that occur annually from contagious or infectious diseases might be prevented, and the average duration of human life considerably lengthened thereby.

As the education of the public increased, so did the demand for accurate knowledge concerning the causes of disease and the methods for its prevention. Laws were enacted in several States creating boards of health, which should make these investigations, and the system was completed when, in 1879, Congress created the National Board of Health, whose duty it should be to make investigations into the causes and means of prevention of contagious and infectious diseases, to initiate measures of national importance, and to be a centre of information for all matters relating to public health. So valuable has been the work of this Board, during its short career of four years, that something more than a passing notice seems to be merited. The following sketch of its history and work has been compiled from notes furnished the writer by Dr. Stephen Smith, a member of the Board, to whom he feels himself greatly indebted:

"The National Board of Health was the direct outcome of the great yellow fever epidemic of 1878," which, among other valuable lessons, taught

the people that "there are pestilences of a national character, which in their devastations, know no municipal or State limits, and that in their control and suppression the National Government should bear its proper share."

So thoroughly were the people roused to the necessity of a department of health at the seat of the central government, that Congress, on assembling in December, at once appointed Committees on Epidemic Diseases in both Houses, which resulted in the passage, March 3, 1879, of an Act creating a National Board of Health. The Board was composed of seven civilians appointed by the President, who in addition detailed officers from the Marine Hospital Service, War Department, Navy Department, and Department of Justice, to act as ex-officio members. Owing to the nearness of the several Departments, the ex-officio members, forming, together with two of the appointed members, the Executive Committee, could be summoned in a few moments to the rooms of the Board. "No emergency, however urgent, could, therefore, occur which it was not possible to meet properly and timely." The full committee was called whenever the exigencies of the case demanded it. The members of the Board were representative men in their several sections, and its executive committee brought to the daily discharge of duty the efficiency of a single hand and the wisdom of the combined experience of the four chief executive departments of the Government.

The operations of the Board, under the Act, were: 1, the collection of information, from health organizations and sanitarians, as to the best plan for a national public health organization; 2, the collection of information regarding the sanitary condition of some of the principal cities and towns of the United States; 3, the appointment of a commission to investigate yellow fever in the Island of Cuba; 4, the collection and collation of the sanitary laws of the United States and of the several States; 5, an investigation as to the best method of determining the amount and character of the organic matter in the air; 6, an investigation into the effects of disinfectants; 7, an investigation as to the composition and merits of patent disinfectants; 8, an investigation regarding the prevalence of the adulteration in food and drugs; 9, a preliminary inquiry with regard to the diseases of food-making animals; 10, an examination of the flow of sewers in relation to their sizes and gradients; 11, a sanitary survey of the eastern coast of New Jersey bordering on New York Harbor; 12, a sanitary survey of the city of Memphis; 13, an inquiry as to the hygiene of the mercantile marine; 14, an investigation of the outbreak of diphtheria in Northern Vermont; 15, an investigation as to the influence of various soils upon sanitation, especially with regard to drainage and methods of disposal of excreta.

In June, 1879, the Board was given additional power by Act of Congress, enabling it to act effectively in case of a reappearance of yellow fever.

The *Bulletin*, published under this act, was recognized as "one of the most important sanitary periodicals in the world, as it contained, not only a complete summary of the progress of epidemic diseases in all countries, and of the state of the public health of every city of the United States and of the seaport towns of the world, but in it appeared all the investigations of the committees of experts appointed by the Board."

In order to meet the apprehended reappearance of yellow fever, sets of rules and regulations were carefully prepared, one to be enforced on railroads, another at seaport quarantine, and the third for steamboat and river travel and traffic. Owing to the efficient way in which these regulations

were carried out "travel and traffic was but little impeded, where the year previously it was entirely suppressed by the shot-gun policy, or complete non-intercourse." Although the work of the National Board was enlarged so as to reach every threatened community in the Mississippi Valley and on the Gulf Coast, its operations were strictly limited to aiding local and State authorities in their struggle with the epidemic. The experience with this epidemic proved conclusively the value and necessity of a central health organization at Washington, and also that "when there is concert of action among the health authorities of the States and the National Board of Health, the most destructive and irrepressible pestilence known cannot make headway; but may not only be controlled, but completely suppressed."

To prevent the recurrence of the epidemic, preventive measures were adopted, one of the most important of which was the creation of insular refuge stations at points on the Atlantic and Gulf coasts, where all infected vessels could be quickly cleaned and disinfected before they entered the harbors of seaport towns. They were designed to aid local quarantines which had not the means to provide all the apparatus necessary for the immediate cleaning of vessels. Of their value to the seaport towns of the Gulf and Atlantic coasts, the health authorities of those sections bear the most positive testimony.

The International Sanitary Conference, held in Washington early in 1881, was at the invitation of the National Board, and the propositions there agreed upon "will doubtless be the basis of international co-operation to prevent the spread of epidemic diseases."

In 1882 the Board organized and carried out, in co-operation with State and local Boards, a system of inspection of emigrants, with a view to the suppression of small-pox which was being introduced into the Western States by unvaccinated persons. Previously to the organization of this service, severe outbreaks of small-pox were of almost daily occurrence in this section; but when it was fully developed, they decreased in frequency and soon ceased to occur.

The circumstances that led to a suspension of the work of the Board can best be given in Dr. Smith's own words.

"Among the appropriations set apart annually by Congress for the use of the National Board of Health was $100,000, as a contingent epidemic fund. This fund was to be used at the discretion of the Board, and with the approval of the Secretary of the Treasury, in the aid of local health authorities, for the control and suppression of epidemics. Although yellow fever appeared at one or two points in 1880 and 1881, yet the Board was able to meet the contingencies which occurred with its ordinary appropriations, and turned over to the Treasury, at the close of each year, the $100,000. In 1882 the $100,000 was, as usual, set apart by Congress, among the appropriations for the Board, as a contingent epidemic fund, but with the proviso that it was to be used at the discretion of the President. The President transferred that discretion to the Secretary of the Treasury, who decided to confer upon the Marine Hospital Service (a branch of the Navy Department) power to perform all of the required sanitary work, and disburse therefor the epidemic funds. In this manner, the functions of the National Board of Health were, without legislative action, transferred to another branch of the service. In the following year, 1883, the Secretary of the Treasury made the same disposition of the fund, and the Marine Hospital Service assumed the duties imposed. Meanwhile the general appropriations to the National Board were with-

held, and on June 2, 1883, the Act of June 2, 1879, expired. At the close, therefore, of the fourth year of its labors, the National Board of Health practically ceased operations. Of the vast service which it rendered to the country during its short, active existence, in the control and suppression of epidemic diseases, the health authorities of the country, and the people of the Mississippi valley, bear grateful testimony. Of the value of the great number and variety of investigations into the obscure origin, and the methods of prevention of pestilential diseases which it instituted, and, for the most part, carried to their final determination, scientific men in all parts of the civilized world have expressed their appreciation. Whatever may be the future destiny of the present National Board of Health, it has accomplished one important result, viz.: it has demonstrated the fact that there must be a permanent department of public health in the general government."

Although the existing State Boards of Health, in their reports, show, in most instances, gratifying progress, their usefulness is often seriously interfered with, first, by a lack of public recognition of the importance of their work, and a consequent unwillingness on the part of State and municipal authorities "to appropriate anything like the amount of funds needed to secure the carrying out of measures necessary to secure the public health;" and second, by the appointment of members who have exceedingly vague ideas in regard to their duties as health officers. In spite, however, of much that is discouraging, these boards are doing much to control disease as well as collecting data showing the physical conditions of the States in their relations to health and disease, such as that relating to natural and artificial drainage, water-supply, forests, rainfall, climate, etc.

The relations between dampness of soil and consumption having been shown by Dr. Bowditch to be those of cause and effect, and later by Dr. Buchanan, of London, the subject of subsoil drainage, and the consequent lowering of the level of the ground-water, is being taken up more and more. Without exception, where lands have been reclaimed by embankments, or marshes have been drained, malarial fevers have decreased, and the general health of the community has greatly improved. In Michigan the decrease in malarial fevers, consequent on drainage, is estimated at seventy-five per cent.

Vital statistics—though receiving attention from most boards of health—registration is not yet sufficiently thorough to allow of any deductions being made from the returns. The laws are still defective in many States, and accurate returns cannot be expected till proper and sufficient legislation is secured. There is little uniformity in the method of publishing the statistics, and no system of registry of physicians and midwives, by which a registrar can know who are properly qualified. Many States seem unwilling to pass any laws whatever on the subject of registration. Dr. John S. Billings, in a report to the National Board of Health, says: "Of the twenty-three States which have had registration laws, only eight have published statistics which can be said to have any scientific value, and none of them have published results as complete as those attained under the English Registration Acts. It will be seen also that the supposed, and probably in most cases the real, cause of failure of these registration acts in this country has been the want of sufficient compensation to the registering officers, and that the successive amendments to the registration acts that have been made in the States which have secured the best results, have consisted essentially in increasing the pay of the registrars." As an

accurate record of the births, marriages, and deaths in any community is absolutely necessary before proper measures can be adopted aiming at the prevention and stamping out of disease, the gradual education of the people to the need of sanitary measures will, no doubt, result in the enactment of the necessary laws.

The State Boards, acting as central bodies, have generally striven to organize Local Boards of Health in the various cities, towns, and villages of their States, whose objects should be: "1st. The creating of channels of information to the people in a form which would most successfully reach the masses, by being placed in the hands of those who could appreciate and would use the information. 2d. The formation of organized bodies through which the statistics in regard to public health could be gathered from all parts of the State. 3d. To ascertain the existence of preventable causes of disease in their communities and to destroy these causes." These local boards are increasing in number year by year, as fast as prejudice is removed and the opposition that is persistently offered to them in many towns gives way before accumulated evidence of the preventable nature of many diseases. In some of the States these boards have almost unlimited authority in their special province, and great care is therefore required in the appointment of their members, so that no political considerations or personal schemes shall in any way injure their efficiency.

Active and aggressive sanitary journalism has influenced the lay press to devote much space to the consideration of subjects relating to the public health. The popular interest thus awakened has resulted in the formation of sanitary associations which are doing good work in educating the public.

The first of these associations formed in this country was the "Sanitary Protection Association" of Newport, R. I., which following the plan of a similar organization in Edinburgh, was in its turn followed by those of Lynn, Mass., and Orange, N. J., till at the present time one hundred and seventy communities have like associations. Their objects, being about the same in every case, may best be given by an extract from the rules of the Lynn Association. These state that the objects shall be, "1st. To promote a general interest in sanitary science, and to dispense among the people a knowledge of the means of preventing disease. 2d. To secure the adoption by the city authorities of the most effectual methods of improving the sanitary conditions of the city. 3d. To provide its members, at moderate cost, with such skilled inspection as shall secure the proper sanitary condition of their own premises and those of other persons in whom they may be interested." Besides distributing vast numbers of sanitary tracts, and information relating to public health, the Newport Association, in 1880, offered prizes "to the person, not the owner of the house occupied, who shall put his or her premises in the most satisfactory condition, and keep them so" for a stated period, and "to the house-owner who shall do the most in a given time, toward improving the sanitary condition of any occupied dwelling." Like anything aiming to improve the condition of mankind, these associations encounter many obstacles. Strangely enough, one of the most formidable with which they have to contend is indifference and ignorance on the part of their members. The results, however, that have been attained are such as to make it extremely desirable that other towns and villages should adopt the same plan.

This sketch would not be complete if mention was not made of the work of the American Public Health Association. Beginning with a very

small membership in 1872, this Association has now grown to be one of the largest and most influential of our national societies. It was organized for the mutual benefit and co-operation of health officers and others who are thinkers and workers in the field of preventive medicine. Its constitution states that its objects "shall be the advancement of sanitary science and the promotion of organizations and measures for the practical application of public hygiene." It has done good work in the diffusion of knowledge, by providing an audience for those who have made researches into the causes of diseases and the best means of avoiding or preventing them, as well as in urging upon the authorities the importance of sanitary legislation. Little interest was manifested in its meetings until the epidemic of 1878, when the public became suddenly aware of the importance of its deliberations and conclusions. Every subject that can possibly be suggested in the vast field of sanitary research receives careful attention, and the reports and papers that are presented at the meetings, together with the discussions that follow, are printed annually, and form a series of volumes containing not only much that is valuable, but also, it is to be regretted, giving space to much that is worthless.

Aiming at the same general work of educating the masses, several of the State Boards of Health have adopted the plan of holding sanitary conventions, or councils, in various towns throughout the State, at intervals during the year, where topics relating to State medicine are freely discussed. In speaking of the conventions in that State, the Secretary of the Michigan Board of Health, in his report for 1882, says: "Their good effects are apparent in the after-results in the towns where such conventions are held. In most instances the citizens are aroused to the necessity of establishing and maintaining an effective board of health; more efficient measures are taken for the suppression of outbreaks of contagious diseases; a better understanding of the necessity for cleanliness, good sewerage, and good ventilation prevails; the relations between the people and the health authorities are more cordial, and a stronger support is given to the health officer in his effort to administer the public health laws."

Measures for the control of contagious diseases have been introduced by most of the boards, with marked success in many instances. The cases, when found, are immediately isolated, and, if possible, placed in temporary hospital structures. As the result of its experience in dealing with this class of disease, the New York State Board of Health in 1882 distributed to local boards through the State a circular giving directions for procedure in cases of epidemics, with diagrams for the erection of temporary hospitals. In the city of New York both small-pox and typhus fever are now considered to be under perfect control. The methods adopted in that city for dealing with these scourges is to isolate a case as soon as discovered, disinfect the premises where it has been found and closely watch all suspicious persons till the period of incubation has passed. Owing to these measures a threatened epidemic of typhus fever last spring was promptly brought under control.

The subject of vaccination has received a great deal of attention of late, and scarcely a report from a board of health fails to devote space to it, showing that the prejudice that still exists against it in some minds is gradually being removed. It is still, however, a mooted question whether vaccination should be made compulsory or not. Some States, such as Illinois and New York, require public-school children to be vaccinated before entrance, and certificates are given if the operation has been successful, without which a child cannot enter a school. Considerable success

has attended the methods pursued in New York City. The Board of Health of that city employs a corps of inspectors, whose duty it is to visit every tenement-house and public school twice during the year, examining each child, and offering free vaccination to every one in the tenements. From October 1, 1874, when this work was begun, to July 1, 1883, there have been 130,598 primary, and 452,550 re-vaccinations, making a total of 583,-148 operations performed by this corps. The records that are kept by the Department show that about ninety-five per cent. of the primary, and about sixty per cent. of the re-vaccinations are successful, and that protection from small-pox is assured in every case. The great numbers of immigrants that are constantly passing through the city make the mortality returns for the year much higher than they would otherwise be, as the cases of small-pox are confined to this class of the population, the older inhabitants that have been successfully vaccinated experiencing complete immunity from the disease.

The pollution of rivers in this country has not yet received the attention it deserves. Special reports have been made from time to time, but they, as a rule, cover only the case of the stream under litigation, when riparian or other rights are infringed, and have no bearing on the general subject.

Food and drug adulteration has received much attention, and four States have passed laws for its prevention. Nothing more, however, than a passing notice of the work in this direction is necessary, as the subject is treated at length in one of the articles that follow.

Many of our older cities have sewerage systems that seem to have been the result of chance instead of prearranged and carefully studied method. Flat-bottomed sewers, covered watercourses, and badly constructed oval sewers, which have been aptly described as "elongated cesspools," are, in some instances, the only means for removing the sewage from the vicinity of dwellings. Cesspools are still in use in many cities, towns, and villages, but are fast disappearing under the vigorous measures of boards of health. Too much cannot be said against their use under any circumstances. The almost depopulation of the city of Memphis, in 1878, is a terrible example of the loss of life that may be occasioned by their use. Much more attention is now, however, being paid to systematic sewerage; new towns are employing competent engineers to prepare plans for its proper disposal, and old ones are seeking advice for the improvement of their existing systems. There has been some controversy of late on the comparative merits of what are termed the "combined" and "separate" systems, the former providing for the removal of both sewage and rainfall through one set of pipes, and the latter requiring a separate system for each. No hard-and-fast rules can, however, be given for the employment of either system; local considerations and future wants should, in all cases, determine the use of either, or a combination of both.

Within the past few years the problem of how to remove house waste in suburban districts has been solved by the employment of a system of subsurface irrigation. The efficiency, simplicity, and comparative cheapness of this mode of sewage disposal makes it available for small plots of ground, and at the same time has none of the dangers of the old system of leaching cesspools.

Although the condition of our public schools is beginning to receive official attention, and the grosser sanitary evils remedied, there is yet comparatively little interest taken in such matters by the public at large. Much has been done, and is being done; but those who recognize the evils of

imperfect heating and lighting, uncomfortable seats, defective plumbing and ventilation, crowded rooms, climbing stairs, badly constructed and dirty closets, impure water, etc., are often sadly hampered in their efforts at reform by causes that are very well put by Mr. Warren R. Briggs, in a recent report of the Michigan State Board of Health, who classifies them as follows: 1, The stereotyped school-house is always before them (the advocates of a better system), and is usually taken as a model for the new building; 2, Local prejudice against sanitary reform—the ancient inhabitant classes it with all the modern crazes and new-fangled notions; 3, Penurious and short-sighted economy in the appropriation of small sums for the construction of buildings; 4, The difficulty of obtaining satisfactory data. This last class has, in a great measure, been removed by competition for prizes offered by the editor of the *Sanitary Engineer* for the best plans for school buildings, which, by directing the attention of architects and others to the matter, has now made it possible to obtain plans for schools of varying size, admirable in construction and ingenious in arrangement.

Municipal boards of health have not been behind, and in some instances have led, the State boards in their work of sanitary reform. The New York City Board was the first to organize, and being the pioneer in municipal hygiene has borne the brunt of the battle against ignorance. Its methods have been closely watched, and many of its regulations adopted by other cities.

Another competition, also originating with the *Sanitary Engineer*, was opened in December, 1878, and a prize of $500 was offered "for the best four designs for a house for workingmen, in which might be secured a proper distribution of light and pure air, with an arrangement of rooms that would yield a rental sufficient to pay a fair interest on the investment." This competition attracted great attention, and so aroused the public to the evils of the then tenement-house system that "an amendment to the Tenement-House Act was passed by the State Legislature, May, 1879, limiting the space to be occupied by any tenement-house to sixty-five per cent. of the lot it occupies, requiring all bedrooms to have windows, with direct light and air, and greatly adding to the powers of the Board of Health to remedy abuses in such buildings."

A very important move was made in 1881, when the State legislature passed a law requiring the registration of all plumbers in New York and Brooklyn, and giving the municipal board of health the power to make such rules as it might think proper for the regulation of the plumbing and drainage in all buildings to be erected subsequent to the first day of October of that year. Plans must be submitted to the Board for approval, and powers were given it to compel compliance with the rules and regulations by making the violation of them a misdemeanor. These rules embody the very best and latest practice in such matters, and their enforcement has already greatly improved the sanitary condition of the city. Inspectors are employed to examine periodically each building in course of erection, and to report any violation of the plans submitted to and approved by the Board. From October 1, 1881, to October 16, 1883, plans for 4,489 buildings have been submitted. These figures will not, of course, agree with the records of the Building Department, as they represent only those houses that contain plumbing, and therefore come under the jurisdiction of the Board of Health. Of these 4,489 buildings 2,808 were tenement-houses, with accommodation for 133,473 persons. The beneficial effects of the "plumbing law" cannot be accurately measured till the lapse of several years has made the collection of statistics possible;

but the providing of over a quarter of a million of people with healthy homes has undoubtedly already improved the condition of the city, a result that will be more and more apparent, as the years pass, in the gradual lowering of its death-rate.

Following the lead of New York, several other cities have adopted similar plumbing laws, the enforcement of which is, in every instance, accompanied with the like good results.

In 1880 the Health Commissioners of Chicago were authorized to inspect the factories of that city, and since that time great improvement has been made in their management and condition, by preventing injuries to employés from moving machinery; by the removal of injurious dust and vapors; by providing proper ventilation for workrooms, and means of escape in case of fire; and by improving the condition of the plumbing and drainage.

The above sketch will, it is hoped, give the reader some idea of the work that has been done, and is still being done, in this country in the department of preventive medicine. The success that has attended the labors of State and local boards of health and of volunteer associations, especially within the past few years, shows a constantly increasing knowledge of sanitary matters among the people generally, which every physician and scientific man should strive to direct in proper channels by all the means in his power. There are, it is true, some few individuals who, by wild and unwarranted statements of the dangers to health from various causes, attempt to make capital by the excitement they create. These, however, together with those who still ridicule sanitary reform as a new-fangled notion, must surely give way before the honest and legitimate labor of trained scientists. It must be admitted that the horizon is still dark in most of the States; but with the tremendous strides made by the nation in other directions, the time cannot be far distant when Sanitary Science shall be given its proper place throughout the length and breadth of the land.

In conclusion, the editor wishes to express his obligations to those who have been associated with him in the preparation of this Supplement for the articles they have contributed, and on which articles the work is dependent for its value.

F. N. O.

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WATER.

By ELWYN WALLER, PH.D.,
Chemist to the Health Department of New York City.

Necessity for Water.—It is impossible to over-estimate the sanitary importance of water for the welfare and comfort of man. For the preservation of a proper degree of cleanliness of our persons, our clothes, our dwellings, or the articles with which we have to come in contact, it is indispensable.

As regards our food, it must be remarked that about 73 per cent. of the human body consists of water, and the food proper to nourish one should contain about 81.5 per cent. of water. What is termed "solid food" contains, roughly speaking, from 50 to 80 per cent. of water, and thus to make up the necessary amount of water, some must be drunk as water, or in some beverage of which water is the chief constituent. A healthy man weighing 11 stone (154 lb) requires every twenty-four hours about 5½ pints of water in some form or other. When the amount of water in the system is diminished by about one per cent. of the whole, the sensation of thirst is felt, which we usually allay by imbibing the needful amount.[1]

In brief, water is a prime necessity for human beings, both externally for cleanliness, and internally as food.

Sources of Water.—The water which we require in our daily life and avocations, comes to us more or less directly from the clouds, as rain or snow.

The rain water may be collected directly as it falls, or it may soak into the earth and flow forth again as springs, forming eventually ponds, streams, or rivers, or it may penetrate deeper and require us to dig wells in which it may collect.

Our sources of supply may therefore be classified as Rain water, Surface water (including springs, ponds, streams, rivers), and Well waters.

From none of these sources, however, can we obtain water which is chemically pure (*i. e.*, nothing other than the compound of oxygen and hydrogen known under that name), because water is the great solvent in nature and dissolves some of every substance, gaseous or solid, with which it may come in contact. Many of these substances are beneficial, most of them are harmless, while some are not only hurtful, but may even be deadly.

Term "Impurity."—In speaking of those substances dissolved by natural water many persons, no doubt following the lead of chemists, call them all "impurities," which is correct in the sense that they are not water; while sanitarians frequently use the term impurities to designate only those sub-

[1] Church, Plain Words about Water. Pamphlet. London, 1877.

stances in natural waters which are dangerous or inimical to health. Confusion often results from the use of the term impurity in these two different senses, and some bridge the difficulty by calling the hurtful impurities "contamination" or "pollution."

Kinds of Impurity.—Using the term "impurity" in its widest sense, the different kinds of impurity which may be met with in water are Gaseous, Mineral, and Organic (Vegetable and Animal).

The mineral and organic impurities may be dissolved in the water, or partly dissolved and partly suspended (still in solid form). The particles suspended may be in so finely divided a condition as to elude the eye, and the water appear clear and bright.

Gases.—The gases constituting the air itself—oxygen, nitrogen, and carbonic acid—as well as those resulting from electrical disturbances of the atmosphere, as ammonia and nitric acid, are all dissolved to some extent by water. In addition, some springs and bodies of water may contain sulphuretted hydrogen, either from the decomposition of the constituents of the rocks through which the water percolates, or the action of organic matter upon the sulphates in the water, or other gases may be present, resulting from conditions peculiar to the locality (the vicinity of volcanoes, etc.). Moreover, in the vicinity of towns and manufactories, the air may contain various gases resulting from the presence of numerous human beings, from the combustion of coal, or from numerous manufacturing operations, which impurities will be imparted to the water.

Mineral Matters.—The mineral matters floating in the air are washed from it by the rain. After reaching the earth the rocks and soil with which water may come in contact, yield to it some of their mineral constituents. The salts almost invariably found in terrestrial water are carbonates, sulphates, chlorides, silicates, and nitrates, of potassa, soda, lime, magnesia, iron, and alumina. Other elements may occur in some localities, and when the amount or the kinds are such as to impart to the water a medicinal value, we may have the so-called mineral springs. The waste waters from manufacturing operations, which find their way into our ponds and water courses, either directly or indirectly by percolation, may also introduce mineral matters into water. Moreover, sewage contains considerable quantities of mineral matters which may reach our sources of supply by similar channels.

Organic Matters.—The water draining from swamps, from forests, or in short from any places not destitute of vegetation, always contains vegetable matters, more or less decomposed. Moreover, especially in the neighborhood of human habitations or industries, the water percolating through the soil usually contains organic matters of animal origin, which, on account of their instability, are passing through the changes known as decomposition.

Agents of Decomposition.—The purest atmosphere is full of particles of organic nature which are so small as to defy the powers of the microscope (Tyndall, "On Haze and Dust"); yet many of these particles are the germs or spores of organisms (presumably vegetable in their nature), which are the microscopical or ultra-microscopical agents of decomposition. Organic material from which the mysterious principle we call life has departed, is the congenial soil in which such organisms flourish and reproduce their kind, or such modifications of their kind, that the germs of some of them, when introduced into the human body by the air we breathe or the water we drink, produce disease.

The germs from the development of organisms of this class in decom-

posing vegetable matter, though not in all cases altogether innocuous, are much less inimical to human life than some of the agents of the decomposition of animal matters.

Of the nature of these germs we have very little knowledge—so little, indeed, that doubts have been expressed as to their existence; but the "germ theory of disease," though but a theory or hypothesis, seems to fit the observed facts so completely that it has been very generally accepted.

Drinking-Water and Disease.—Disturbances of the digestive organs, manifesting themselves as diarrhœa or dysentery, are believed to have been frequently caused, sometimes by the mechanical action of finely suspended mineral matter, or of lime or magnesia salts in a drinking-water,[1] more frequently by the presence of considerable amounts of decomposing vegetable matter. Malarial or remittent fever is also believed to result from this cause.[2]

Typhoid fever and cholera are among the most serious forms of disease which have been in many cases traced to the use of water containing decomposing animal matters (sewage, etc.), and in some cases it has been thought that certain outbreaks of yellow fever, typhus, diphtheria, and tuberculosis were also attributable to this cause.[3]

Some investigators, chief among whom is Prof. Pettenkofer, refuse to accept this "drinking-water theory," as it is called, maintaining the so-called "telluric theory," according to which the character of the soil, together with various conditions induced in it by meteorological changes, are the principal factors in producing these diseases.[4]

The diseases mentioned have appeared, and have been spread in ways often only explicable by the theory that the imbibition of water, contaminated by decomposing organic matter (perhaps infected by the discharges of a patient) have been the direct cause of the disease.[5]

It cannot, of course, be claimed that contaminated water is the only possible means of spreading these diseases, or that some persons may not have such powers of resistance as to drink the infected water with impunity; some of the advocates of the "telluric theory" are willing to go so far as to admit that the drinking of contaminated water may create a *predisposition* to such diseases.[6]

[1] Wolffhügel, Wasserversorgung, p. 77. Leipzig. 1882.

[2] Woods, Chemical News, vi., 307; Smart, National Board of Health Bulletin, i., 317.

[3] Nichols, Water Supply, p. 19. New York, 1883.

[4] As regards Typhoid Fever, vide Pettenkofer, Zeits. f. Biol., 1870, abstracted also in Report of State Board of Health for Massachusetts, for January, 1871 (2d Report), p. 112; also for January, 1877 (8th Report), p. 117. As regards Cholera, vide Pettenkofer and Decaisne, Les Mondes, xliv., p. 587, etc.

[5] Cases of remittent fever from foul cistern water, "in the absence of prominent sources of malarial exhalation, to account for the presence of the disease," are mentioned by Dr. Smart (loc. cit.). Dr. Woods (loc cit.) speaks of two ships sailing from Algiers for France at the same time. The one took swamp water, and the crew were afflicted with ague; the other took upland water, and had no illness of the kind on board. Occurrences of typhoid fever under similar conditions are reported by Dr. Atwood and Dr. Vinal. (State Board of Health for Massachusetts, 10th Report (1879), Supplement, pp. 270 and 272.) Several similar cases are quoted by Dr. Chandler (Lecture on Water, pp. 36–39. pamphlet, Albany, 1871), and in the 6th Report of the English Rivers Pollution Commission (pp. 140–184). In some of these cases instances have been known of whole bodies of persons living or working in the infected district (workmen in a factory, etc.) who did not drink the water and escaped the disease, while some individuals, being quite at a distance, who did drink the water, were attacked (6th Report, Appendices, p. 497). The abandonment of the infected water has also prevented the spread of the disease. (Millbank Prison, vide 6th Report, p. 163.)

[6] J. v. Fodor, Boden und Wasser. Brunswick, 1882.

Sewage may, perhaps, generate Typhoid Fever, etc.—Many cases have occurred in which typhoid fever at least, and perhaps cholera, have seemed to be *generated* in decomposing sewage, though this question is at present regarded as an open one.[1]

Sewage may not cause Disease.—It is, however, undoubtedly true that water contaminated with sewage may be drunk without causing any specific disease, but aside from the sentiment of disgust which such a proceeding inspires, it is evidently in the highest degree dangerous.

A good water for household purposes should have the following characters:

The temperature should be at least ten degrees lower than that of the atmosphere, but it should not be much below 45° Fahrenheit.

It should be agreeable to the palate, having, perhaps, a slight pungency, from the presence of oxygen or carbonic acid.

Characteristics of a Good Water.—Water containing some of the most dangerous forms of decomposing animal matters, may often be very pleasant to the taste; hence it appears that the palate cannot be depended upon in judging of the safety of a drinking-water.

It should be free from odor, even when warmed. Suspended matters should not be present.

The solids remaining on evaporation should not exceed 50 parts per 100,000 (about 30 grains per gallon). Less than two parts of organic matter is regarded as admissible, but the quality of the organic impurity is much more important than its quantity.[2]

The hardness should be small. The extreme limit for its equivalent, carbonate of lime, is set by some as high as 30 parts per 100,000 (about 17½ grains per gallon).

The amount of chlorine in chlorides should be small, = 5 parts per 100,000 (3 grains per gallon) is the limit assigned by some.

The amounts of ammonia and nitrates should be quite small, while nitrites should be entirely absent.

The properties of the different forms of water available for domestic uses must here be considered.

Rain Water.

Amount.—The mean annual rainfall for different portions of the United States may be thus briefly stated.[3]

	Inches.
Northern States (East of the Rocky Mountains)	30 to 50
Southern States	50 to 70
Between the Rocky Mountains and the Pacific Coast Range	10 to 20
San Francisco	20 to 25

[1] Dr. Jaccoud, after critically examining the evidence regarding 105 cases of outbreak of typhoid fever (Congrès d'Hygiène, 1878, i., p. 377), concluded that in 45 of these cases the evidence was insufficient, in 36 there was evidence that it had been transmitted from patients by the dejecta and excreta, and in the remaining 24 excrementitious matter unmixed with the excreta of persons suffering from the disease, seemed to have generated it *de novo*. Vide Braithwaite's Retrospect, Part lxxiv.; also Brit. Med. Jour., May 27, 1876.

[2] "The Organic and volatile matter," or "loss on ignition," reported by chemists in analyses of water, does not necessarily represent organic matter entirely. (See p. 424.)

[3] Taken from Map of Signal Service Papers, No. ix., Lieutenant Dunwoody.

Proceeding along the Pacific Coast northward from San Francisco, the rainfall becomes heavier, amounting to between 70 and 80 inches at Vancouver Island. In all cases, as one recedes from the coast the rainfall diminishes. For New England and the Middle States, in calculating for public water supplies, 40 inches is taken as the average.[1]

One inch of rain would amount to nearly 101 (gross) tons per acre,[2] or on a house roof of say 20 x 20 ft. area, one inch of rain would be about 250 gallons. With a rainfall of 40 inches per annum this would amount to 10,000 gallons, or about 27 gallons per day.

The average daily supply *per capita* in most of our northern cities ranges from 20 to 127 gallons or more.[3]

Source of Impurities in Rain Water.—The impurities in rain water are derived from the atmosphere through which the rain falls, from the surface upon which it is received, the receptacles in which it may be stored, and from the emanations or infiltrations which may reach it when stored.

Atmosphere.—Air contains on an average about 0.5 gramme of solid matter per 1,000 cubic metres,[4] which is equivalent to a little over 0.2 grain per 1,000 cubic feet. The amount, however, is subject to very wide variations. It is stated[5] that "a half-pint of rain water often condenses out of 3,373 cubic feet of air; and thus in drinking a tumbler of such water, impurities which would only gain access to the lungs in about eight days are swallowed at once." The average composition of seventy-three different samples of rain water, collected twenty-five miles from London, on a specially prepared surface, etc., may be here quoted as representing approximately the constitution of rain water falling in an open country, by the time it reaches the earth.[6]

	Parts per 100,000.
Organic carbon	0.099
Organic nitrogen	0.022
Ammonia	0.050
Nitrogen as nitrates and nitrites	0.007
Chlorine	0.63
Hardness	0.62
Total solids on evaporation	3.95

A set of examinations conducted under similar conditions in this country, might possibly, on account of different climatic conditions, show a greater degree of purity in the rain water. The water, however, would not be pure.

If zymotic diseases prevail in the neighborhood, it is quite probable that the germs of disease might be thus washed into the drinking-water. At any rate, in the neighborhood of collections of houses, or of manufactories, or both, the impurities in the rain water from the air would no doubt be very much increased.

Surfaces for Collection.—The surfaces upon which rain water is usually collected are, almost without exception, the roofs of our houses. Whatever the material of the roof, the rain falling upon them after a period of fine weather, first washes from them more or less of the dust, excremen-

[1] J. T. Fanning, Water Supply, Engineering, pp. 46 and 98. New York, 1878.
[2] A. H. Church, Plain Words about Water. London, 1877.
[3] Fanning, loc. cit., p. 39.
[4] Remsen, Report of National Board of Health, p. 73, 1879.
[5] 6th Report Rivers Poll. Comm., p. 30.
[6] Loc. cit., pp. 27 to 29.

tal or other, minute plants, spores, and germs, etc., which may have lodged upon them. Cases have also been known where ignorant or lazy servants have emptied slops from the upper windows of a house on projecting roofs below. To avoid the introduction into the cistern of such material as may be washed from roofs by the first portions of a rainfall, "cut offs" have been invented, some of them automatic, by which the first portions of the rain are run to waste, and only the purer after-fall is turned into the cistern. They appear, however, to be but little used.[1]

Material of Roof Surface.—The material of the roof surface has a considerable influence on the character and quality of the water. From painted roofs it takes up some of the constituents of the paint, from galvanized roofs some of the zinc, and so on. From shingled or tiled roofs the rain may wash the small mosses and small plants which may have germinated upon them; from shingled roofs may also be washed particles of the wood disintegrated by weathering, which are transferred to the cistern to decay there. The best material for a roof on which the rain water is to be collected is slate, which is sufficiently smooth to afford comparatively little opportunity for the lodgment of dust, vegetable growths, etc.

Cisterns: Wood.—The material of the cistern also requires consideration. Wood cisterns are very prone to decay, the inevitable alternate wetting and exposure to air to which the sides of the cistern are subjected by the fluctuations of the water-line being especially favorable to such decay, the result being the introduction of considerable quantities of dissolved and suspended matters into the water.

Lead Linings.—Lead linings are more readily attacked by rain water than by any other, and should never be used for cisterns. The solution of lead is aided by dissolved air, by nitrates and by chlorides in water, while it is obstructed, and often prevented by the presence of sulphates, phosphates, and lime salts.[2] The presence of more than three volumes of carbonic acid per 100 volumes of water, is also stated to prevent the action of water upon lead.[3] Cistern water contains less of the protecting substances, and more of those aiding the solution of lead than any other.

Cement Linings.—Cement linings, containing as they do more or less lime, are apt to render the water hard, and on that account are objectionable. They are also liable to crack and allow of leakage from the cistern, or worse still, the leakage of sewage matters into the cistern.

Slate Linings.—Slate linings are not open to the objections raised against the others, except that attention to the composition of the cement by means of which the slabs are joined is requisite. Lead oxides are often used in these cements, with the result of contaminating the water with lead.[4]

Location of Cisterns.—If placed above ground, cisterns should be sheltered from the sun, both in order to keep the water sufficiently cool to be palatable, and to retard or partially prevent any decompositions of material which may gain access to them. If below the surface, especial care has to be used to prevent the infiltration of various slops, etc., which may be thrown or fall upon the ground near the house. Contamination in this manner is very frequent with underground cisterns, either from the porosity of the material with which it is lined, or the occurrence of cracks in

[1] Dr. Smart, loc. cit.
[2] W. S. Saunders, Chem. News, xlv., p. 7.
[3] Report of English Commission of 1851. Graham, Miller, and Hofman, quoted in 6th Report, loc. cit., p. 224.
[4] Phipson, Chem. News, xl., 1.

the cistern. One of the samples of cistern water examined by the English Rivers Pollution Commission,[1] was found by them "to consist of sewage of even greater strength than average London sewage" from this cause.

Sewer-gas in Cisterns.—Another source of dangerous impurity in cistern water is sometimes the arrangement adopted of having the overflow pipe of the cistern in communication with the soil pipe of the house, by which the noxious gases from the house sewage gain access to the water and are absorbed by it.

Other Impurities.—Cisterns are often the resorts of the rats, mice, cockroaches, and other small vermin about a house, and the excreta or dead bodies of such vermin are frequently found in those receptacles. Their possible presence adds still another danger to the safety of the water.

A few of the numerous analyses of stored rain water may be here quoted. A few of them have been selected as showing how impure a cistern water may become.

ANALYSES OF CISTERN WATER.

Results expressed in Parts per 100,000.

Location.	Total Solids.	Ammonia.	Albuminoid Ammonia.	Hardness.	Chlorine.	Analyst.
Podehole.....	5.28	0.00		3.8	0.9	Riv. Poll. Comm.
Sheffield Barracks.	12.00	0.130		5.0	1.6	" " "
Greasely.....	126.60	0.730		55.70	11.5	" " "
Boston, Mass.....	5.28	0.013	0,008		0.32	W. R. Nichols.
Newport, R. I....	7.50	0.0105	0.0275	3.73	0.76	E. Waller.
Omaha, Neb.....	6.70	0.012	0.0136	4.03	trace	"
Cincinnati, O.....	2.68	0.004	0.123		0.55	C. H. Stuntz.
" ".....	4.48	0.027	0.118		1.97	" "
Wilmington, N. C..	5.05	0.002	0.015		0.70	C. W. Dabney.
" "	6.90	0.016	0.008		0.52	" "

Dr. Smart describes the cisterns so largely used in New Orleans in a report to the National Board of Health.[2] They are usually constructed of cypress wood, the average capacity being about 2,000 gallons. "Many are in unventilated enclosures, rank with the emanations of unclean privies.

"The rain water shed from the house roof carries with it into the cistern the soot and condensed ammoniacal vapors of coal combustion, the infinity of debris, organic and inorganic, which constitute the dust of a large city, together with more massive fragments, as of dead insects and decaying leaves, etc. After a few days these various matters settle, forming a soft, black pultaceous sediment, and leaving the supernatant liquid comparatively clean and pure," etc. The average rate of accumulation of sediment is about one inch per annum. An analysis of the air-dried mud from one of these cisterns showed—

	Per cent.
Moisture	17.2
Organic and volatile	34.0
Mineral matter	48.8

[1] Sixth Report, p. 29. Greasely cistern water in the table appended.
[2] National Board of Health Bulletin, i., 317.

On account of the numerous sources of danger to the purity of stored rain water, most authorities unite in condemning it for general household purposes, though for laundry purposes alone it is usually the best water.

In Holland, where rain water is collected among the sand dunes at some distance from the cities, and from those receptacles is conducted to the centres of population, as Amsterdam, rain water is regarded as the best form of water obtainable.[1]

The conclusions of the Rivers Pollution Commission[2] regarding rain water are as follows:

"1. Of the various kinds of water used for dietetic and domestic purposes, *rain water*, when collected at a distance from towns upon specially cleansed surfaces, and kept in clean receptacles, contains the smallest proportion of total solid impurity; but the organic contamination, even of such specially collected water, somewhat exceeds that of water from springs and wells.

"2. Rain water collected from the roofs of houses, and stored in underground tanks, is much more impure; it is often polluted to a dangerous extent by excrementitious matters, and is rarely of sufficient good quality to be employed for dietetic purposes with safety."

Snow.—Snow is quite as impure as rain, perhaps in many cases more so. Tissandier obtained the following results with snow after it had been melted:

	Solids per 100,000 parts.
Falling in a court in Paris	21.2
Falling on towers of Notre Dame	11.8
Falling in the open country	10.4

About 60 per cent. of these solids was mineral matter. Besides various mineral salts the snow also contained ammonium nitrate.[3]

The amount of ammonia, and hence probably the amount of organic impurities in snow, has been found to vary with the temperature at which it falls, and the nature of the surface on which it falls.[4]

Many hold the opinion that snow water is unwholesome. Dr. Chas. Brewer, U. S. A., speaks of the Western mountaineers attributing to the use of snow water the origin of the so-called mountain fever.[5]

Surface Water-Springs.

Spring water usually comes to the surface after having undergone a filtration through a mass of soil and rock, compared with which the filter beds used by water companies or corporations in purifying the water supplied to consumers are insignificant.

The amount yielded by them is naturally more dependent upon the rainfall of the district than upon the nature of the geological formation. The quality is, however, dependent upon the geological character of the rocks through which the water has passed. All of the mineral constituents

[1] Congrès d'Hygiène, 1878, ii., p. 100.

[2] Sixth Report, p. 424.

[3] Comptes Rendus, January, 1875.

[4] Vogel, Akad. d. Wissenschaften Münschen, part I., 1872. Boussingault found in freshly fallen snow 0.178 part of ammonia (per 100,000). After the same snow had lain on a garden soil for a day and a half, it contained 1.034 part (Wolffhugel, Wasserversorgung, p. 9).

[5] Vid. Smart Buck's Hygiene, ii., pp. 129 to 134.

of those rocks are taken up by the water to some extent. In general terms, the older non-calcareous rocks—granite, sandstones, etc.—afford the water freest from mineral matters, while calcareous formations usually give up the most mineral matter to the water.

A water is considered usable in respect to mineral matter if it does not contain over 30 grains of solids per gallon (50 parts per 100,000). Calcareous strata also not only give up more mineral matters to water, but also, among other elements, the water takes up considerable quantities of lime and magnesia, which cause the "hardness" so objectionable in water, especially for washing and cooking.

Character of Water-bearing Strata.—The character of the material through which the water may percolate is of some importance. Rocks containing many fissures often yield water of doubtful quality. The water from gravelly deposits also is variable in quality, no doubt in both cases the result of imperfect filtration.

Avoid External Contamination.—The above is applicable to the water from springs where there is no opportunity for contamination by drainage from heavily manured fields, or perhaps houses and barnyards. If, for instance, a spring issues near the base of a hill on which are located farmhouses with their accompanying outhouses, as well as cesspools, barnyards, pigstyes, and the like, the probabilities of the contamination of such a spring are very great. In such cases, however, the dip of the strata by which the water is to some extent guided, might become a factor in determining the chances for or against the desirability of the water for domestic uses. The external configuration of the land is not always a guide as to the probable lay of the strata beneath.

Constancy of Flow.—Aside from the question of the probable ability of a spring to always meet the demand which may be made upon it, the constancy of flow in a spring is usually a valuable indication. Springs of variable volume generally draw their supply from a near and limited area, and the water from them is more likely to be contaminated than that from those yielding a more constant supply, and presumably drawing from a larger and more thoroughly filtered source.

Composition of Spring Waters from Different Formations.

Results given in Parts per 100,000.

Formation.	Total Solids.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates, etc.	Chlorine.	Hardness.	Number of Samples.
Granite and Gneiss Rocks	5.94	0.042	0.008	0.001	0.106	1.69	3.0	8
Silurian Rocks	12.33	0.051	0.014	0.001	0.178	1.84	6.8	15
Devonian Rocks and old Red Sandstone	25.06	0.054	0.012	0.001	0.764	3.85	12.0	22
Yoredale and Millstone Grits and Coal Measures	21.91	0.050	0.014	0.001	0.393	1.85	13.1	22
Lias	36.41	0.073	0.019	0.001	0.467	2.48	30.1	7
Oolites	30.33	0.043	0.011	0.001	0.402	1.55	24.4	35
Chalk	29.84	0.044	0.010	0.001	0.382	2.45	23.6	30
Fluvio-Marine, Drift, and Gravel	61.32	0.086	0.019	0.001	0.354	2.76	37.6	10

Contents.—Organic matter is usually present to some small extent, but if pollution by excrementitious matters is prevented or excluded, it is usually harmless.

The preceding is a portion of the table giving the average composition of unpolluted waters examined by the English Rivers Pollution Commission.[1]

Summary.—Spring water, when surface pollution is avoided, is regarded as the best possible kind of water for general domestic uses. When the water reaches its outlet through a very permeable stratum (gravel or fissured rocks), it may not be sufficiently filtered to have the desirable qualities common to spring waters as a class. In limestone regions it may also be too hard for comfort or economy in the household.

Surface Water.—Ponds and Streams.

Amount.—It is estimated that about half of the water descending upon the earth as rain, finds its way into the streams.[2]

Impurities: Mineral.—The character and amount of the mineral impurities in ponds and streams, is to some extent dependent upon the character and amount of those constituents in the springs which supply them, and upon the geological formation where they may be. The amount, however, is usually smaller, partly because these sources receive some of their water directly from the rain that either falls directly upon their surfaces or runs into them during a rainfall, without passing through the ground, and partly because the plants growing in them abstract some of the mineral matters for their own sustenance and growth.

Organic.—On the other hand, the water in ponds and streams is exposed to influences tending to increase the amounts of organic matter. The plants growing in the water or along its margins afford some of this; the dust and leaves borne by the wind contribute to it, and in the vicinity of human habitations and manufactories, the sewage and manufacturing refuse work their way into them, imperfectly filtered by the adjacent soil, or are turned into them directly without any such partial filtration.

Watercourses are the natural drains of a country, and hence the appearance of such material in the streams and rivers is inevitable. Consequently the quality of the water of streams is better, as a rule, the nearer we approach to the source.

Suspended Impurities.—Besides dissolved impurities, surface waters naturally contain various matters in suspension, which vary in quantity and character with the weather, and in each individual case with the topography of the country, the character of the rocks and soil of the water shed, the presence of towns, manufactories, etc. As a sample of the same river at different times and different places, with regard to its contents in suspended matters, the following results of observations on the Rhine may be of interest:

[1] 6th Report, p 131.

[2] Fanning, loc. cit, p. 77.

Suspended Matter.[1] (*Parts per* 100,000.)

	By Weight.	By Volume.
At Strasburg, July and August	2.00	
At Bonn		6.25
At Bonn	20.50	
At Bonn, after dry weather	1.73	
At Uerdingen, after sudden floods	78.00	
In Holland		1000.00

A table of analyses of some of the river waters in the United States is here given. The increase of material of various kinds in some of these rivers, as we descend the stream, is noticeable.

Rivers in the United States. (*Results in parts per* 100,000.)

River.	Place.	Date.	Mineral Matter.	Organic and Vo'atile.	Total Solids.	Chlorine.	Ammonia.	Albuminoid Ammonia.	Hardness.	Analyst.
Mississippi	Minneapolis, Minn.	1877			18.6	1.1	0.003	0.015		S. P. Peckham.
Mississippi	St. Louis, Mo.	Aug., '73	240.1	4.2	244.3	1.21	0.002	0.068	11.47	D. V. Dean.
Mississippi [2]...	St. Louis, Mo.	Aug., '73	45.04	2.1	47.14				8.22	D. V. Dean.
Ohio	Cincinnati, O.				14.2	0.8	0.011	0.048		C. H. Stuntz.
Ohio	Louisville, Ky.	1880			11.7	0.6	trace			T. C. Van Nuys.
Ohio	Evansville, Ill.	1880			18.6	0.9	0.012			T. C. Van Nuys.
White.....	Indianapolis, Ind.	1880			28.0	0.4	0.003			T. C. Van Nuys.
Cumberland...	Nashville, Tenn.	Sept., '76			13.80	0.3	0.000	0.0035	7.86	N. T. Lupton.
Cape Fear....	Wilmington, N. C.	Aug., '81		...	5.6	0.4	0.008	0.016		W. R. Nichols.
Hudson	Albany, N. Y.	March, '72	9.30	1.2	10.5	0.52			6.00	C. F. Chandler.
Hudson	Poughkeepsie, N.Y.	Nov., '77	10.40	1.7	12.1		0.0109	0.0197		W. R. Nichols.
Hudson [2].....	Poughkeepsie, N.Y.	Nov., '77			10.1		0.0109	0.0184		W. R. Nichols.
Croton	New York, N. Y.	'72 to '82	5.702	1.678	7.380	0.3	0.001	0.012	3.21	E. Waller.
Schuylkill.....	Philadelphia, Pa.	July, '81			12.01	0.56	0.002	0.012	8.6	H. Leffmann.
Passaic	Falls, N. J.	July, '72	5.28	2.58	7.86	0.432	0.040	0.040		H. Wurtz.
Passaic	Belleville, N. J.	July, '72	7.36	1.95	9.31	0.470	0.049	0.085		H. Wurtz.

Examinations of Water from Lakes and Ponds.

(Results given in parts per 100,000.)

	Place.	Analyst.	Date.	Org. and Vol.	Mineral.	Total Solids.	Hardness.
Lake Michigan.....	Chicago, Ill.....	Blaney..	1859	1.81	9.63	11.44	
Lake Erie	Cleveland, O.....	Cassels..	Feb., 1866	1.10	8.23	9.33	3.00
Lake Ontario.....	Toronto, Can.....	Croft ...	Feb., 1878	0.77	11.73	12.50	
Lower Chain Lakes.	Halifax, N. S.....	Lawson .	Sept., 1878	3.83	3.49	7.32	
Lake Massabesic...	Manchester, N. H..	Hayes...	June, 1869	2.77	1.93	4.70	0.84
South Pond	Plymouth, Mass....	Nichols .	June, 1877	1.40	1.60	3.00	
Watuppa Pond	Fall River, Mass...	Appleton	1870	1.43	1.67	3.10	0.34
Lake Konomoc	New London, Conn.	Nichols .	Dec., 1879	1.20	1.60	2.80	
Artificial Lake.....	Norwich, Conn.....	Silliman.	Jan., 1873	1.16	2.0	3.16	0.93
Lake Owasco	Auburn, N. Y.....	Chandler	1876	1.20	15.80	17.00	8.7
Green Lake.....	Syracuse, N. Y.....	Chandler	Jan., 1871	1.20	14.14	16.34	
Reeds Lake.....	Grand River, Mich.	Kedzie ..	Aug., 1872	Much.	12.86		
Blue Lakes	San Francisco, Cal.	Falkenau	April, 1875			21.0	

[1] Vid. Nichols, Water Supply, Table vii., p. 57.

[2] Filtered.

The "places" mentioned are those for which the water was either proposed or used as a source of public supply. In a few cases the lake or pond is a considerable distance off, *e.g.*, the "Blue Lakes, San Francisco, Cal.," are high up on the Sierra Nevada, 8,000 feet above the level of the city.

Purification of Rivers by Flow.—The question of the self-purification of rivers by their flow has been earnestly discussed, and cannot be regarded as settled at the present time. Such purification would take place by the oxidation of the dangerous organic material, by deposition of the suspended material, carrying with it some of the organic impurities, or by the agency of organisms in the water, as fish, water plants, or the more minute algæ, some forms of which possibly feed upon or destroy the as yet unrecognized "somethings" which cause disease. Dilution of the water in its progress causes an apparent and perhaps a real purification.

The results of series of experiments made by the English Rivers Pollution Commission[1] would go to show that oxidation alone is insufficient to purify the water of a stream in which the water has been once fouled by sewage.

Dr. Tidy[2] claims that the rapidity of oxidation depends on, *a*, the degree of dilution of the sewage; *b*, the distance of the run; *c*, the rapidity of the current; *d*, the temperature, and *e*, on certain natural or physical conditions: *e.g.*, if the bed is rough, so that the water has a greater opportunity for aëration, or there are numerous locks, weirs, etc., along it, which may produce the same effect, the purification is more rapidly effected than where the stream flows quietly along. By arranging the experiment in a different manner to that of the Rivers Pollution Commission, he obtained results which he interpreted as indicating that the organic impurities in a river would be materially reduced by oxidation in a flow of a few miles. He adduces statistics to show that the death-rate in towns supplied by river waters is less than in those supplied from deep wells, and also asserts that there is no case of water of a river, after receiving sewage, having caused an outbreak of disease after a flow of ten or twelve miles.[3] The subsidence of mineral matter, carrying with it some organic impurities, and the influence of fish, etc., he regards as aids to such purification.

The influence of water plants and organisms as agents of purification is also dwelt upon by others.[4] Many of these authorities also mention that plants, etc., remove chlorides and other mineral constituents from the water.

W. R. Nichols[5] suggests that "the apparent self-purification of rivers is largely due to dilution, and the fact that a river seems to have purified itself at a certain distance below a point where it was certainly polluted, is no guarantee that the water is fit for domestic use." In this connection it must not be forgotten that rivers usually receive large additions to their volume by subterranean infiltration, which is none the less real because out of sight.

[1] Sixth Rept., pp. 134–140.

[2] Journal of Lond. Chem. Soc., xxxvii., 268.

[3] An outbreak of typhoid fever in a hospital using river water, where the disease was traced to a barracks *twenty-five miles* up the stream, is quoted in Mass. State Board of Health Report, 1876, p. 284.

[4] R. Warington, Chem. News, xli., 265; E. J. Mills, ib., xli., 260. The discussion between Drs. Frankland and Tidy on this subject may be found in Jour. Lond. Chem. Soc., xxxvii., 268; also Chemical News, xli., 245, and xlii., 113.

[5] Water Supply, p. 69. New York, 1883.

Dilution of a contaminated river may render it difficult or impossible to decide, by chemical analysis, that pollution exists, but we cannot rest satisfied that dangerous contamination does not exist in it on that account.

Summary.—In conclusion it must be said, with regard to ponds and streams as sources of water supply, that where contaminating influences of cultivated land, manufactures, and house drains, etc., are absent, they are good sources of supply, though perhaps at times charged with suspended matter, which should be removed by subsidence or filtration, or both. Ponds and lakes where the water is stagnant should be regarded as suspicious or dangerous, but where the water in them changes frequently they are safe. Rivers and streams are always better (as regards safety for health) nearer their sources. After having once received sewage they may perhaps be safe if they have flowed for some distance, but the use of water from such streams is not advisable if any better supply can be obtained.

Wells.

Amount.—It is estimated that about one-fourth of the rainfall of a district penetrates into the ground, and may be obtained by sinking wells.[1]

As with springs, a variable supply shows a near source.

Kinds of Wells.—The ordinary forms of open wells have been roughly classified into shallow and deep wells, according as they are less or more than about fifty feet in depth. We may have also drive wells,[2] made by driving a pointed iron tube down into the ground to any desired depth, and (what are infrequently used for household supplies) artesian wells made by boring.

Impurities: Mineral.—With regard to any or all of them it may be said that the mineral impurities are usually larger than in the case of pond and river waters, varying very much (as in the case of springs) with the geological formations which the water may have traversed; usually the deeper the well the more mineral matter it contains.

Organic.—Almost all of them contain some organic matter. The organic matter of a dangerous character comes from sources at the surface, house drains, manufactures, etc., and if a well penetrates below the influence of such impurities, and infiltration of such surface waters are excluded, water of good (sanitary) quality may be obtained.

There is a widespread belief that water becomes purified by filtration through the soil. This is true, but not to the extent generally supposed. The purifying power of the soil is much more limited than is usually imagined, and the amount of material to be destroyed, as well as the time necessary for its destruction, are factors in the question which are usually lost sight of. A soil becomes very rapidly saturated with material of a dangerous character to have in our drinking-water,[3] and the unlimited purifying power with which it is generally credited is, in fact, very limited after all, unless opportunity is afforded for the operation of what might be termed the regenerative forces of nature.

Distance to which Contamination may reach.—Cases occur almost every day where householders will triumphantly state that their wells are a cer-

[1] Fanning, Water Supply, Engineering, p. 102.

[2] Called in England "Abyssinian wells," because used by the British army in the Abyssinian campaign.

[3] For experiments on this point, vid. v. Fodor, Boden und Wasser. Brunswick, 1882.

tain number of feet (usually less than twenty) from any cesspool or drain, and that therefore they cannot conceive of any possible danger to the quality of the water. As a matter of fact, polluted water may travel a great distance. In the cases of infected wells, etc., hereinafter quoted (p. 432), the wells were 30, 60, and even 100 feet distant from the cesspools or privy vaults through which the infection was communicated, and connection between the two was satisfactorily proved in the case where the well was 100 feet off. A case of pollution of a well by gas-works 1,000 feet distant is also on record.[1] Finally, reference may be made to the Lausen epidemic of typhoid fever,[2] where a subterranean flow of over a mile failed to remove the infectious material from the water.

Organisms may be carried through Soil.—That organisms can also penetrate the soil to indefinite distances, probably borne by the "ground-water," is strikingly shown by the experiences in Berlin and other places in Europe, where a number of wells were visited, about the same time, by numbers of one of the numerous forms of algæ frequently to be found in water (*Crenothrix Kuhniana*), a plant possessing marked characteristics. Sinking fresh wells was of no use, as the plant made its appearance sooner or later in all of them, and the whole system of wells was finally abandoned.[3]

Some have claimed that the water draining from cemeteries is not dangerous.[4] It is also asserted that though decomposing urine and excrement, when undiluted, are poisonous or deadly, sewage diluted a hundred thousand times is harmless;[5] but few will care to experiment upon themselves or their families with any such dilutions, under the name of drinking-water.

Pleasant Flavor of some Contaminated Waters.—A treacherous quality of many polluted waters, especially in the case of wells, may be here noted. It has been frequently observed that many contaminated waters are exceedingly palatable, often more soft to the taste, and more clear and sparkling, than waters which are free from contamination.

These properties are not invariably present, but when they are, it is often a matter of great difficulty to persuade the owner of a well that contamination exists or is even possible.

Sewage not always Fatal.—Undoubtedly, diluted sewage (which is in many cases the proper term for the liquid in some wells) can be drunk without invariably causing disease; but, aside from the sentiments of disgust which such a proceeding inspires, the risk of the generation of disease, or the contamination of the water with the excreta of persons affected, is too great to be hazarded.

Impervious Strata.—If an impervious stratum interposes between the well-curb and the water of the well, and the infiltration of surface water is prevented at the top, the conditions are extremely favorable for the purity of the water, which, under such circumstances has usually undergone a thorough filtration. The well then partakes of the character of an artesian well.

Although all rocks are probably to some extent permeable to water, those which are so slightly, so as to be classed as impermeable, are granite,

[1] Fischer, Dingl. Polyt. Jour., ccxi., 139.
[2] Deutsche Vierteljahr. für Off. Gesundhtspf., vi., 154. Quoted in Report Mass. State Board of Health, 1877, p. 124.
[3] Nichols, Water Supply, p. 125.
[4] Wolffhugel, Wasserversorgung, p. 27.
[5] Emmerich, Bayr. Akad. d. Wiss., ix., 381.

serpentine, trap, gneiss, mica slate, argillaceous slate, and clays.[1] Such formations may, however, be permeable, on account of the presence of fissures caused by geological disturbances. Fissures are less likely to exist where the strata are nearly horizontal, or have a slight inclination, than where they have been more disturbed, and consequently stand at a greater angle to the horizon.

Lay of Strata.—The position of the strata has an important influence on the quality of the water in relation to filtration from the surface. The writer has had occasion to examine the water from numerous wells (drive wells and others) sunk on Manhattan Island, the depths varying from a few feet to one thousand or more, and has found that none of them could be regarded as safe for household uses. The strata on the island stand at angles varying from 80° to 90° with the horizon,[2] or nearly vertical, and as the tendency of the water is to follow the direction of the strata, a well sunk at one point, however deep, draws its supply from the water which has penetrated the surface not very far off, and in such a densely populated district, all the water soaking through the ground becomes practically sewage, and is in the highest degree dangerous for use. London and Paris can sink their artesian wells and obtain wholesome water, since they are situated in geological basins, and the water from those wells has filtered into the water-bearing stratum from considerable distances outside of the city limits; but New York is not so favorably situated.

Intercepting Wells.—Most of the wells located along the valleys near the banks of streams do not draw from the streams, as is frequently supposed, but really intercept the water which is on its way to join them by subterranean channels. This affords an explanation of the fact that fresh water can usually be obtained by digging along the sea-shore above high-water mark. The water in such wells may fluctuate in level in unison with the fluctuations of the level of the body of water near which it is situated, simply because the pressure of the water in the stream or other body of water is communicated to the feeders supplying it. It is, however, not well to trust so far to the expedient of catching the water before it gets into the stream, to expect to obtain pure water by sinking a well close to the margin of a stream which is seriously polluted. The saturation of the ground with material which will sooner or later make its way into the wells, and when there, will thoroughly pollute the water, is sometimes a slow, but none the less sure process.

Summary.—Of all the sources of water supply, wells are the most exposed to the danger of contamination, and require the most careful watching.

The depth is not always of so much importance as the exclusion of surface drainage. The loosely laid stones around the sides of most wells are no protection against percolation of objectionable liquids into a well, no matter what its depth.

Driven wells are not much safer than the ordinary form, unless they penetrate an impermeable stratum in their course.

In locating a well, careful attention is necessary to the respective situations and depths of the cesspool, the privy vault, the kitchen drain, and the barnyard or stable.[3] Sources of contamination external to the premises where the well is located must also be considered, as cemeteries, manufac-

[1] J. T. Fanning, Water Supply, Engineering. p. 103.

[2] W. W. Mather, Natural History of New York, part iv., Geology, pp. 519 et seq.

[3] Vid. Report on Martha's Vineyard, Mass. State Board of Health, 1879, Supp., pp. 163–198.

tories, etc. Even much-travelled streets may cause some contamination of a well water.

As regards the relative position of such sources of contamination, the character of the soil, the lay of the underlying strata where that can be ascertained, and other local conditions, are factors in the question. For instance, it would be obviously dangerous to place a well between a cesspool and the sloping margin of a stream, since the drainage naturally tends toward the stream bed.

In cities or parts of towns where the houses are close together, wells should never be used.[1] In towns or villages where there may be a house every hundred feet along the street, the danger of contamination of the well water is usually great.[2] Even with isolated farm-houses, the quality of the water needs constant and vigilant attention.

The composition of sewage in different cities is given below[3] in parts per 100,000 :

Composition of Sewage.

	Boston, Mass.	Worcester, Mass.	Average for 50 English Cities and Towns.	Berlin, Prussia.
Total solid matters in solution....	58.96	25.35	72.2	78.9
Total suspended matters.....	37.34	21.16	44.69	51.0
Organic nitrogen			2.205	1.23
Total combined nitrogen			7.728	
Ammonia.....	2.72	1.876	6.703	
Nitrogen as nitrates and nitrites..	0.036	0.134	0.003	
Chlorine	18.94	4.17	10.66	
Phosphoric acid	1.69	0.66		1.58

Classification of Waters as regards Quality.—The following classification of waters "with respect to wholesomeness, palatability, and general fitness for drinking and cooking," is given by the English Rivers Pollution Commission :[4]

Wholesome.	Spring water.	Very palatable.
	Deep well water.	
	Upland surface water.	Moderately palatable.
Suspicious.	Stored rain water.	
	Surface water from cultivated land.	
Dangerous.	River water to which sewage gains access.	Palatable.
	Shallow well water.	

Decided preference is given to the first two.

Most other authorities adopt essentially the same view. Wolffhugel[5] gives the preference to pure spring and well water (provided the hardness

[1] The Rivers Pollution Commission (6th Report, p 284) advised the closing of all the wells in London but three, which were exceptionally placed.

[2] Vid. Fanning, Water Supply, p. 139.

[3] Report of State Board of Health of Massachusetts, January, 1876, p. 398.

[4] Sixth Report, p. 129.

[5] Wasserversorgung, p. 203. Leipzig, 1882.

is not such as to be objectionable), giving the second place to the water from streams and rivers, the next to that from ponds and lakes, and the last place to rain water. As regards the last, he considers that only in case of urgent necessity should it be used for any other purposes than for washing.[1]

A table of the results of analyses of the water of wells, two of them of fair quality and two much polluted, is also here given.

WELL WATERS.

Results given in Parts per 100,000.

	Fair.		Polluted.	
Appearance	Faintly turbid, colorless.	Clear, light bluish.	Clear, light blue.	Turbid, yellowish.
Odor	None.	Slight.	Sweetish.	Foul.
Chlorine in chlorides	0.527	0.877	15.114	24.103
Phosphoric acid in phosphates	None.	None.	Trace.	Much.
Nitrogen in nitrates and nitrites.	0.091	0.252	11.53	4.035
Nitrites	None.	None.	Trace.	Much.
Free ammonia	None.	0.0004	0.0072	0.620
Albuminoid ammonia	0.004	None.	0.0022	
Oxygen absorbed 15 minutes	0.0244	None.	0.028	0.265
Oxygen absorbed 3 hours	0.0244	0.0054	0.028	0.337
"Hardness"—before boiling	1.874	19.23	51.7	32.019
"Hardness"—after boiling	1.106	3.72	39.2	30.935
Organic and volatile matter	1.60	1.50	44.90	59.40
Mineral matter	5.70	22.90	157.10	127.70
Total solids on evaporation	7.30	24.40	202.00	187.10

PURIFICATION OF WATER.

What is effected by Purification.—We cannot expect to render a foul water good by any of the methods here enumerated, but these processes may serve to improve a water unsatisfactory in some respects for the purposes to which it may be desired to put it.[2] They are serviceable as a possible though uncertain safeguard.

Water may be safe for drinking and other household purposes, but it may contain suspended matter rendering it unsightly to the eye and harsh to the palate, or may temporarily contain harmless algæ which give it an unpleasant odor or taste. It may also contain such considerable quantities of lime salts that it is inconveniently hard for washing purposes, not to mention the considerable expense involved in the destruction of soap, which the presence of much lime entails, an item in household expenses which is not always recognized as preventable.

Boiling.—Boiling is one of the oldest and simplest modes of improving the quality of water. The effect is partially (or if the boiling is sufficiently

[1] Wasserversorgung, p. 210. Leipzig, 1882.
[2] Fischer, Chemische Technologie des Wassers, p. 199. Brunswick, 1878.

prolonged, entirely) to destroy many of the minute organisms present in almost all waters.[1] The boiling also sets free the carbonic acid present, by the aid of which the water holds many mineral substances in solution, chief among which is a considerable proportion of the lime which makes it hard.

The lime and other mineral matters, except alkalies, existing in the water as carbonates, may be thus rendered insoluble, and if the water is allowed to stand a short time these matters collect in flocks and settle to the bottom, carrying with them much of the organic impurity, leaving the water clear and bright.

The water, however, having lost its dissolved gases by this process, has a somewhat flat taste, which may be remedied by pouring the water back and forth through the air a few times.

Settling.—Suspended matters may be completely removed by simply allowing the water to stand quietly and deposit them. The kind of material constituting the suspended matter, and its physical condition, together perhaps with the character of the salts dissolved in the water, makes, however, a great difference in the rapidity of the deposition. For example, the Mississippi River at New Orleans is often turbid with microscopic particles of clay. On allowing the water to stand, the grosser particles settle in twenty-four hours, but the finer particles require several days.[2] With some other turbid waters, a few hours' standing is sufficient.

Salts used to hasten Deposition.—The addition of various salts to the water has a marked effect in clarifying it by deposition. A table of the comparative influence of some of these salts, arranged so as to give approximately the quantities which have equal effects, is given below.[3]

Chloride of sodium (common salt)	4680.0
Sodium bicarbonate (cooking soda)	672.0
Calcium chloride	222.0
Magnesium chloride	182.0
Carbonate of lime, dissolved by carbonic acid	100.0
Carbonate of magnesia " " "	84.0
Sulphate of lime	136.0
Proto-sulphate of iron (green vitriol, copperas)	22.80
Proto-carbonate of iron, dissolved by carbonic acid	17.40
Alum	7.92
Perchloride of iron	2.74

Armengaud[4] advises the use of sulphate of iron. Alum has been recommended by numerous authorities,[5] the proportion to be added being one part to five thousand of water, or about one ounce to every forty gallons.

In Canada a mixture of powdered alum and borax (three ounces of each)

[1] Forster, Verbreitung der cholera, 73; Church, Plain Words, p. 35.

[2] Rept. of Dr. Smart, Water Supply of New Orleans and Mobile. National Board of Health, i., 317.

[3] Portion of a table given by D. Waldie, in a paper On the Muddy Waters of the Hooghly during the Rainy Season, with Reference to its Purification, and to the Calcutta Water Supply. (Jour. Asiatic Soc. of Bengal, xlii., part ii., 1873.)

[4] Génie Industriel, 1865.

[5] Paris commission, Dingler, xxi., 110; D'arcet, Bull. Sci. Tech., October, 1831, p. 66; Jennet, Compt. Rend., lxi., 598.

to the barrel of water of thirty-one and a half gallons is used,[1] while ferric chloride (perchloride of iron) is recommended by Peligot [2] and Gunning.[3] The latter adds it in the proportion of thirty-two parts per million or one ounce per two hundred and fifty gallons, and to neutralize any acidity, and remove any excess of iron, this addition is followed up by the addition of $2\frac{2}{3}$ ounces of carbonate of soda to the same quantity of water. This process has been applied by him on a large scale at Rotterdam, on the water of the Meuse.

Hager [4] asserts that the addition of a small proportion of tannin to water not only kills the algæ present, and precipitates them from the water, but prevents the communication of disease by the drinking-water. After the addition of the tannin the water must be allowed to stand some hours. Langfeldt [5] recommends for the destruction and precipitation of algæ the addition of 1 part of citric acid (the acid of lemon-juice) to 2,000 of the water (1 ounce to about 16 gallons).

It may also be added that iron in contact with water is asserted by some to have a purifying influence,[6] and some recommend the use of iron filings or scraps for purifying waters.[7] An objection to this would be the solution of some of the iron, which might in some cases be objectionable in washing, etc. Permanganate of potassium alone or mixed with lime, or permanganate of lime are suggested.[8]

Clark's process for softening hard water is one of the oldest and best known methods of treating water. It is believed that, besides softening the water, it improves its sanitary quality.[9] It consists in adding lime-water to a water, by which means the carbonic acid holding lime in solution is fixed, and both the added lime and that originally present in the water precipitate together as carbonate. For a water the hardness of which is equivalent to from 20 to 30 parts of carbonate of lime per 100,000 (about 10 to 20 parts of which is temporary—removable by boiling), he recommends about 9 ounces of quick-lime for 400 gallons of water, or 1 gallon of clear lime-water to every 10 gallons of the water to be softened.

The addition of a little sodium carbonate (washing soda) and boiling is probably the most convenient and efficient mode of improving the quality of a water for laundry purposes in the household.[10]

Of these different modes of treating water to improve its quality, boiling is the simplest, if we take its efficiency into consideration. The addition of ferric chloride (perchloride or muriate of iron), followed by carbonate of soda, or the addition of alum alone, or alum and borax, in small quantities, may be used with advantage. The use of permanganates, strongly recommended by some physicians to travellers in districts where fevers prevail, is a very doubtful safeguard.[11]

[1] Fanning, Water Supply Engineering, p. 533.
[2] Ann. du Conserv. des Arts et Métiers, v., 60.
[3] Chemical News, May, 1869.
[4] Biedermann's Centralblatt, July, 1878.
[5] Chem. Centralblatt, xii., p. 74.
[6] A. W. Blyth, Effect of Iron Pipes, Chem. News, xxx., 211.
[7] Runge, Technische Chem.; Medlock, Eng. Pat., 1857; Muspratt's Chem., ii., 1085.
[8] Hofmann, Dingl., cliii., 62; Schultze, Dingl., cxix., 188, 210; Crooke's Chem. News, xxviii., 243.
[9] Wanklyn, Water Analysis.
[10] The relative amounts of lime, soda, and soap required to neutralize hardness in water has been given as follows (6th Report Rivers Poll. Comm., p. 205):

1 cwt. lime,
4¼ " carbonate soda,
20½ " soap.

[11] Wolffhügel, Wasserversorgung, p. 216.

Filtration.

Action of Filters.—The principal effect of filtration is to remove the suspended matter in the water. This is effected, no doubt, to a great extent by the arrest of particles too large to pass through the interstices of the filter, also partially by the attraction of the masses in the filter for those in the water. A filter will also often absorb a portion of the gases in the water, and thus effect a removal of some of the dissolved matters. Where the filter is used intermittently, as is apt to be the case with most house filters, and air is allowed to penetrate the filter occasionally, an oxidation of organic material and aëration of the water also may occur to some extent. Certain materials may also abstract portions of the dissolved matters from the water.

Materials used.—Sand, iron sponge, wood-charcoal and animal charcoal (bone black), porous stone, artificial or natural, as well as sponge, wool, and similar organic materials have been used or recommended for the filtration of water. As regards the last-named class of materials, except as rough strainers to remove the grosser particles which may be suspended in the water, they are not serviceable, nor do they have any satisfactory effect on the quality of the water. They can only be used temporarily, as they will in a short time pass into a state where they communicate more organic impurity to the water than they take out.[1] Combinations of these materials sometimes, after treatment with iron salts, alum, etc., have been used.

Sand.—Sand filtration is the nearest imitation of the ordinary natural filtration taking place in the soil. The sand should be well washed and screened, so that all the particles are approximately of the same size.[2] If different sizes are used they should be disposed in layers, the larger sized material at the top. The principal effect of filtration through a bed of sand is the removal of suspended impurities. The organic matter in water is removed to some extent, but less by sand than by other materials of this class. Porous stone, both artificial and natural, is similar in its effects to sand, but is cleaned with greater difficulty.

Iron Sponge.—Iron sponge is made by mixing sawdust and iron oxide (ores or other forms) and heating the mixture in a furnace. A porous mass consisting of an intimate mixture of charcoal and metallic iron results, which has been found very efficient for purposes of filtration.[3] The sponge removes more mineral matter, though less organic matter than bone black.

Bone Black.—Bone black, or animal charcoal, should be thoroughly burned and be fresh when used for filtering purposes. The test applied by the workmen in sugar-houses to determine the quality of the material may be used. The dry black when touched by the tongue should have no taste, but should adhere persistently to the tongue, on account of the absorption of the moisture into the pores. The black should also be dull in lustre.

[1] Alton, Ill., uses sponge. Nichols, Water Supply, p. 168.

[2] The best size for a sand for filtration of water is said to be such that it passes through a screen consisting of 32 or 33 No. 10 wires in six inches. Nichols, Water Supply, p. 155 (foot-note).

[3] Bischof, Proc. Roy. Soc., xxvi., p. 152; Wigner, The Engineer (London), 1879, p. 22; 6th Report Rivers Poll. Comm., p. 220.

The effect of this material is chiefly on the organic matter of the water, though when fresh it will remove a not inconsiderable portion of the mineral (dissolved) matters. This effect ceases to be produced in about a fortnight, though the absorption of the organic matter goes on for some time longer,[1] though to a diminished extent.

Numerous combinations of various forms of carbon (coke, wood-charcoal, etc.) have been used or proposed, but they are inferior in efficiency to bone black in removing the organic matter from water. A form of filtering slabs of animal charcoal is made by Atkins & Co., of London. The material is mixed with tar, moulded into slabs, and then burned. For use these slabs are inserted into frames as window panes are into their sashes. In cleaning them a portion of the surface has to be scraped off.[2]

Filters.—The forms of filters are more varied than the materials used in them. We can here only notice two classes: the small filters attached to a tap which filters the water as it is drawn, and the larger forms. The action of the first class is simply that of any strainer, removing the grosser suspended particles in the water, without otherwise improving its condition. Taking into consideration the amount of water usually run through a tap, and the rapidity with which it is expected to run, it is too much to anticipate that a couple of ounces of bone black or sand will oxidize and destroy an appreciable amount of the organic matter in the water. Any material acting as a strainer will serve the same purpose, and the home-made device of tying a bag of flannel or some similar material over the mouth of the faucet, though not perhaps so elegant in appearance, is as good as any other.

A mixture of bone black and sand is the material most commonly used in these filters. Provision must always be made for washing the filter after a certain amount of use. This is usually effected by having the box carrying the filtering material so arranged that it can be readily reversed, so that the first half-pint of water which runs through it washes away the material which the filter has arrested.

Tank Filters.—Of filters on a larger scale, many different forms are used. Some, used in cisterns or other receptacles for water supplies, consist simply of a porous partition (of brick, porous stone, etc.) between the supply pipe of the tank and the service pipe leading from it. Others consist of a box containing the filtering material attached to the end of the service pipe. The best forms of these last are those in which the water is admitted from the bottom of the filter, which is raised a few inches from the bottom of the tank, so that the sediment of the water may separate out before the water enters the filter, and also that the particles arrested may to some extent fall away from the filter when the water is not being drawn.

The objection to all of these cistern or tank filters is that they are out of sight, and hence often out of mind, and are usually allowed to go uncleaned long after their efficiency has been destroyed by lack of cleansing. The difficulty of cleansing them also helps to contribute to such neglect.

Of filters which may be used to clarify water for household supplies, when the water stands in a receptacle (usually in the lower chamber of the filter) until it is drawn upon, it may be said that the simplest form which admits of the ready cleaning or renewal of the filtering material is

[1] Sixth Report Rivers Poll'n Comm., p. 219.

[2] For description of the manufacture, vid. Am. Chem., v., 301; see also Fanning, Water Supply Engineering, p. 536, and Nichols, Water Supply, p. 178.

the best. It is a great advantage to so arrange the filter that pure air may be drawn into it occasionally, so that water may become aërated in its passage through; the material used in them is usually a combination of two or more.

A cheap form of filter, readily made in any household, is exhibited at the Bethnal Green Museum at London, and called the Poor Man's Filter.[1] It consists of a large earthen flower-pot, the hole at the bottom of which is stopped with a cork through which passes a glass tube. A small piece of sponge is tied on to the upper end of the tube. Over this is laid the filtering material in layers in the following order:

	About
Clean sharp sand	1 inch.
Gravel	2 inches.
Bone black	3 or 4 inches.
Sand	1 inch.
Gravel	2 inches.

This should be covered to exclude dust.

To prevent the water from running too straight, slips of glass may be laid between the layers in such a way that the water must take a zigzag course to reach the bottom.

Dr. Smart[2] describes another form. It consists of a tin tube with cloth tied tightly over the top and the bottom. About three-fourths of its length is filled with bone black, and the upper fourth with sand. Around the top of the tube is a funnel-shaped head, the tube projecting up into it so as to form an angular space in which the sediment may collect without clogging the filter. The head also serves as a support to the tube in the bucket or other vessel which receives the filtered water.

Duration of Filtering Material.—All filters require cleaning, or better still, renewal of the filtering material. The frequency with which this is required depends to some extent on the character of the water, and the amount of suspended and other impurities it may contain. It is stated that a bone-black filter removes some of the mineral matter for about two weeks, after which it has little or no effect upon it, though it will continue to absorb organic matter from the water for a considerable period. After four months filters of sand and wood-charcoal were found to be useless or even foul. Other materials would probably last no longer, and it is perhaps advisable to adopt, as a general rule, that a filter should be cleaned or its contents renewed at least every two months, to insure efficient operation. With waters containing much matter in suspension a more frequent cleaning may be advisable.

Cleaning.—It will be remembered that the layers of the filter which the water first reaches are naturally the most foul, and if the filtering material is easily obtained it would be advisable to renew the first inch or two of the filtering material at every cleansing.

To clean material in grains, as sand, broken bone black, spongy iron, etc., it should be well agitated in a wash-tub or some suitable vessel with water, and the turbid water containing the finer particles run off, while the coarser grains sink to the bottom; this should be repeated several times until the water runs off clear.

[1] A. H. Church, Plain Words about Water, p. 32.
[2] National Board of Health Bulletin, i., 317.

Where the filtering material is in solid masses, or slabs, cakes of porous stone, "plastic coal," charcoal, etc., the surface must be at least brushed smartly with a stiff broom, while a stream of water plays over it. A still better way is to scrape off the outside portion of the slab, to expose a fresh surface. After such cleaning, the material should be dried in the air, that it may aërate the water, when it may be restored to its position in the filter.

Small sand filters may be cleaned by pouring through them a quart of water containing $\frac{1}{10}$ oz. permanganate potash, and $\frac{1}{2}$ fl. oz. muriatic acid, and then running water through it until it has no sour taste. In case this method is used, the vessel containing the filtering material should be of such a nature that it will resist the action of the acid.

The bone black in small filters may be cleaned by boiling it two or three times with water, draining, and drying.[1]

Summary.—No treatment of water by boiling, chemicals, or infiltration can be relied upon to make a water absolutely safe for use, though the quality may be improved, and the risk diminished with a water of doubtful quality.

In the household, boiling is usually the simplest method of improving the quality of a water. A good plan of procedure is to boil the water, and then to pass it through a well-aërated filter.

Of filtering materials bone black removes the most organic matters, spongy iron removes the most mineral matters, wood-charcoal, etc., is far inferior to either, and sand has but little effect except upon the suspended matters.

Filters should be so constructed that aëration of the material is possible, and they should be easily cleaned. The cleaning should be frequent and thorough.

Chemical Analysis of Water and the Interpretation of the Results.

Taking Samples.—In taking samples of water to be sent to an analyst for examination, a glass vessel (demijohn, etc.) of sufficient capacity and thoroughly cleaned should be selected. Earthen jugs are often glazed by the use of salt, and might impart chlorides to the water; their use is best avoided for this purpose. It will be observed that very minute quantities of some of the constituents have to be determined, and a fair amount of the water will therefore be necessary, say one or two gallons. The sample should not be less than one gallon (preferably two). The vessel should not have been used previously for any liquid which cannot be thoroughly removed from it. Wine demijohns are sometimes used in which the sediment from the wine adheres so strongly to the glass that rinsing fails to dislodge it, yet from those crusts the water may absorb enough material while in transit as to utterly mislead the analyst, should he not discover it in time. The vessel, after being thoroughly cleaned, should be rinsed a few times with the water, a sample of which is to be taken. A gallon or two of the water at least should be allowed to run to waste before the sample is taken. The vessel should then be securely stopped with a *clean new* cork, a small air-space being left between the surface of the water and the cork, and the stopper fastened so that it cannot be disturbed in transit.

[1] Vide A. H. Church, loc. cit., p. 33.

The sample also should be put into the hands of the analyst with the least possible delay, since all waters, and especially polluted waters, alter quite rapidly after removal from their sources.[1]

Modes of reporting Results.—The modes of reporting the results of analyses of water are so varied as to be extremely confusing to those for whom the interpretation of them is of the most importance. Some chemists report in parts per million, some in parts per hundred thousand, others again in grains per imperial (English) gallon, which is in effect parts per 70,000, and others again in grains per U. S. gallon of 231 cubic inches (English Winchester gallon), which is, according to some, parts per 58,318 ; others, parts per 58,327.5 ; and others, parts per 58,372.2.

The different values for the U. S. gallon are of but little importance where the quantities estimated are so small, but when the report does not specify whether the gallon used is the imperial or the U. S. gallon, it is a matter of some moment. In this paper the method of parts per hundred thousand has been adopted.

Organic Impurities.—It is evident, from what has been said regarding the impurities of water, that the greatest danger to be feared in water for domestic uses is from the organic matter. Yet almost all the water used by human beings contains some organic matter, and it has been jocularly remarked that tea and coffee, or beef broth, are samples of water loaded with organic matter to which no objection is made. The *kind* of organic matter is then the important point.

Decomposing organic matter in which thrive the germs (or undiscovered "somethings") which produce disease, is the dangerous kind of organic matter, and the wash from marsh land, or still worse, the drainage and sewage saturated with the decomposing refuse of all kinds, which inevitably exists about human habitations, are the bearers of this dangerous form of organic matter.

Analysis directed to Characteristic Constituents.—Since it is impossible to determine absolutely the amount and quality of the organic matter which may exist in a water, the chemical examination is directed toward the detection and estimation of such constituents as may be characteristic of the liquids, of which decomposing organic matter forms a part. A difficulty meets the chemist on the very threshold of such an examination, namely, that the very compounds which he would determine exist also in perfectly pure waters which are altogether uncontaminated. The most, therefore, that he can do is to determine whether the amounts of those compounds in the sample of water submitted to him are in excess of what might be properly expected.

Sewage water is known to be especially dangerous.[2] The characteristic features of sewage are large quantities of organic matter, especially nitrogenous compounds, and the results of their decomposition, carbonaceous matter, ammonia, etc. ; mineral matter, which sometimes includes appreciable amounts of phosphates, and always includes considerable quantities of chlorides and lime salts, especially sulphate of lime.

Magnesia salts predominate in meat, bread, grain, and leguminous products, and are therefore present in excreta of those men and animals using such substances as food ; while lime predominates in the leaves of plants, green vegetables, hay, etc. The excreta of herbivora contain con-

[1] Muir, Chemical News, xxxv., p. 94 ; Wanklyn, Water Analysis, p. 16 ; Chemical News, xxxv., p. 114.

[2] See Table of Composition of Sewage, p. 415.

siderable quantities of potash. Hence large amounts of potash and magnesia salts are regarded as suspicious signs in well waters.[1]

Potassium salts are, however, absorbed by soils in large quantities, and their presence in small quantities cannot, therefore, be regarded as indicating absence of such contamination.

The substances determined in water as aids to a decision regarding its quality are one or more of the following: dissolved oxygen, organic carbon, organic nitrogen, suspended matter, total solids on evaporation, organic and volatile matter, ammonia (free and albuminoid), nitrogen in nitrates, nitrites, hardness (temporary, permanent, or total), chlorine in chlorides, oxygen absorbed (usually from permanganate of potassium), and phosphoric acid in phosphates. Observations may also be made on the temperature, color, odor, and taste. The source of the water, spring, well, pond, or river, must also be taken into consideration, and the surroundings noted.

Suspended Matter.—The determination of suspended matter is usually only roughly approximate. It is usually done by filtering some of the water through a weighed paper, and drying and weighing the paper, or by comparing the weights of the residues obtained by evaporating some of the water both before and after filtration through paper. The physical state of the suspended matter is often of much more importance than its amount. Minute angular fragments are for some persons extremely irritating to the lining membranes of the bowels.

Total Solids.—This is ascertained by evaporating a measured quantity of the water, drying and weighing the residue. It can only be regarded as an approximation, since various forms of organic matter are destroyed or volatilized off by such evaporation,[2] while, on the other hand, many inorganic salts, as sulphate of lime, retain water with great persistency. The results may therefore be below or above the truth. Unless it contains poisonous metals, the amount of total solids considered as admissible in a water for domestic use has been fixed at about 50 parts per 100,000 (about 30 grains per U. S. gallon).[3]

Organic and Volatile Loss on Ignition.—By igniting (heating to redness) the residue obtained by evaporation (total solids), and noting the loss of weight, the result to which the above names have been given is obtained. As a means for determining the amount of organic matter in a water, it is altogether unreliable.[4] Besides the probability already referred to, of a loss of organic matter on evaporation, all the organic matter may not be driven by ignition,[5] and many of the mineral salts present may be decomposed with partial loss of their constituents (as carbonate of lime, which loses its carbonic acid and becomes quick-lime), or partially or entirely volatilized (as potassium chloride, etc.). The indications by this test are therefore of very little value,[6] and many chemists omit to make it altogether. Some chemists, after igniting, add carbonic acid water or carbonate of ammonia solution to the residue, and then dry and weigh, while others do not. The effect of such addition is to convert into carbonates such of the mineral bases as have lost their carbonic acid or other acid

[1] Fischer, Chemische Techn. des Wassers, p. 108. Brunswick, 1878.
[2] Wanklyn, Jour. Lond. Chem. Soc., xx., 445; Frankland, ibid., xxi., 79.
[3] Wanklyn, Water Analysis, 4th ed., p. 3; Bolley, Fischer, Kubel-Tiemann, etc., etc.
[4] Wanklyn, Water Analysis, p. 21.
[5] Frankland & Armstrong, Jour. Lond. Chem. Soc., xxi., 80.
[6] Tidy, Jour. Lond. Chem. Soc., xxxv., 46.

which was originally combined with them. The difference in the results is sometimes very marked.

Many chemists, again, follow the suggestion of Frankland[1] and ignite the evaporated residue, noting the amount of blackening as a rough qualitative estimation of the probable amount of organic matter present. A water, however, which contains considerable quantities of nitrates, and may be very foul, will often show no blackening by such treatment, though a considerable quantity of organic matter may be present, owing to the oxidation of the organic matter during evaporation or ignition by the oxygen given up by the nitrates.

Dissolved Oxygen.—The determination of dissolved oxygen is used by some, especially by French chemists. The value of the determination as giving information of the quality of a water is derived from the view that oxygen is absorbed by the burning up (chemically speaking) the dangerous organic substances present, which are in a state of change. The oxygen dissolved in the water effects this, and if the dissolved oxygen is small, it is because there are in the water substances which are taking it up and therefore are presumably hurtful, *e.g.*, the amounts of dissolved oxygen found in the water of the Seine were found to be[2]—

	C. C. per litre	= Cubic in. per gal.
Before receiving Paris sewage.....	4.34	1.
After receiving Paris sewage.....	1.02	0.23
Normal amount (Boudet[3])	9 to 9.5	2 to 2.2

As water readily takes up oxygen (and other gases) by agitation, or even by contact with air, it is evident that a determination of the dissolved oxygen is of no value unless it is performed on the spot, as soon as the sample is drawn, and even then could be easily made useless.

The water of artesian wells, it is stated, contains no oxygen.[4]

Oxygen Absorbed.—Potassium permanganate is a salt of deep purplish red color; it dissolves in water, giving it a strong red violet tint, and readily parts with a large proportion of the oxygen it contains, affording colorless compounds in the presence of an acid. This salt has been used in a variety of ways to determine the amount of readily oxidizable matters present in a water, and in that way to aid in deciding as to the probable amount of organic matters present.

This test, as will be seen, is the reverse of the preceding. It was first proposed by Forchhammer, of Copenhagen, in 1850,[5] and has been used with various modifications up to the present time.[6] The test is applied in various ways by different chemists; some use an acid, some an alkaline solution; some boil it, others do not; some allow an excess of the permanganate to act for certain stated lengths of time, others add it little by little, so long as the color of the permanganate is destroyed.

These different methods will give very different results with the same sample of water, and hence the results obtained by one chemist may not

[1] Water Analysis, 1880, p. 14.

[2] Assainissement de la Seine, i., pp. 20 and 21. [3] Ibid., ii., p. 8.

[4] Gerardin, Comptes Rendus, lxxviii., 1704.

[5] Frankland, Water Analysis, p. 52. London, 1880.

[6] Vid. W. A. Miller, Journal of the London Chemical Society, xviii., 117; Tidy, ibid., xxxv., 67; Kubel-Tiemann, Untersuch. von Wasser, p. 104, Brunswick, 1874, and others.

be comparable with those obtained by another. The value of the test has been seriously questioned.[1]

Value of Permanganate Tests.—Wolffhugel[2] says: "The action of potassium permanganate without heating is very incomplete; even on boiling in alkaline or acid solution, all the organic substances are not oxidized. Moreover, potassium permanganate is not a sure means of disinfection in the case of ferments which are formed."

The test, though of some value, is by no means entitled to the implicit faith which has been placed in it by many, especially by physicians.

Nitrogen Compounds.—It has been said with regard to the chemical examination of waters for sanitary purposes, that the chemist does not know what he has to look for, and it is not surprising that he finds difficulty in giving a decision. The constitution and properties of the *materies morbi* in a contaminated water are unknown. It has, however, been observed that (comparatively) considerable quantities of nitrogen exist in the organic matter rendering water insalubrious.

Organic Nitrogen and Organic Carbon.—Professor Frankland has proposed the determination of the amounts of carbon and nitrogen present after evaporating with certain precautions, and the relative proportions of those two elements. The results are usually reported as "Organic Carbon" and "Organic Nitrogen." The ratio of carbon to nitrogen for animal matter is put as 3 : 1, while for vegetable matter it is given as 8 : 1.[3] The amount of carbon obtained is the measure of the organic matter, and the proportion of carbon to nitrogen is taken as indicating the character of the organic matter. That the dangerous quality of a water is no doubt proportional to the amount of nitrogen (in combination) it contains was noted in 1856.[4]

The process by which the organic carbon and nitrogen are determined, known as the "combustion process," is one requiring elaborate apparatus and delicate manipulation, to which is added considerable risk of error in the most skilful hands, since the amounts to be determined are usually so small. Hence it is recommended that, even with the most skilful chemists, duplicate or even triplicate concordant results should be insisted upon before accepting the results as trustworthy.[5]

Products of Decomposition of Nitrogenous Matter.—It is generally accepted as a fact that the nitrogenous organic matter in water affords by the process of putrefactive decomposition considerable quantities of ammonia, then of nitrites, and finally nitrates. By this it is not meant that the changes succeed one another sharply, but that when water has taken up organic matters in the first stages of their decomposition, ammonia or substances readily yielding ammonia (albuminoid ammonia) are prominent, and later on, probably by contact with the soil, nitrites and nitrates assume prominence.[6] The change from ammonia to nitrites and nitrates is believed to be due to the action of an organized ferment in the soil,[7] hence water containing nitrogenous matter which has percolated through the soil,

[1] Frankland, Chemical News, xxxix., 70; ibid., Water Analysis, pp. 55 and 56; Wanklyn, Water Analysis, p. 22, 5th London ed., 1876.

[2] Wasserversorgung, 216. Leipzig, 1882.

[3] Frankland, Water Analysis, p. 83.

[4] Hofmann and Blyth, Report on Metropolitan Water Supply, London, 1856.

[5] Mallet, Supp. No. 19, National Board of Health Bulletin, May, 1882.

[6] Trommsdorf, Fres. Zts. Analyt. Chem., ix., 165.; Boudet, Assainissement de la Seine, ii., 5, 1876; Sixth Report River Poll. Comm., p 12.

[7] Houzeau, Comptes Rendus, lxxxiii., 525; Schloesing & Munz, ibid., lxxxiv., 301; Boussingault; Warington, Jour. Lond. Chem. Soc., i., 74, 1878; Storer, Am. Jour. Sci. and Arts, xv., June, 1878; etc., etc.

usually contains considerable amounts of those compounds, while sewage as collected in the sewers has little or none.

Ammonia.—The Nessler reagent (a double iodide of potassium and mercury) is a very sensitive reagent for ammonia, and is the reagent usually used in determining the ammonia in a water. Inasmuch, however, as the presence of various compounds in the water (magnesium salts, sulphides, etc.) interferes with the indications, the usual method is by distillation of a measured quantity of the water, in most cases after adding some alkaline solution (as carbonate of sodium). This method also has the additional advantage of concentrating the ammonia in the first portions of the distillate, as it is carried off by the steam. The result of such test is generally reported as "Free Ammonia," though having reference to the fact that a solution of impure urea when treated in this way yields ammonia, some chemists prefer to call it "ureal ammonia." In fact, the amount of ammonia so obtained represents the ammonia as such, plus that derived from the decomposition of urea or kindred bodies present.

Albuminoid Ammonia.—By the addition of alkaline solution of potassium permanganate and distilling, still another portion of the nitrogen of the organic matter is obtained as ammonia and may be estimated. Since some of the nitrogen of decomposing albumen can be obtained in this way, and decomposing albuminous bodies are believed to be the favorable soils for the development of the germs of disease, this form is called the "Albuminoid Ammonia."

Value of Albuminoid Ammonia Test.—This method of testing water was proposed by Messrs. Wanklyn, Chapman, and Smith,[1] and on account of its delicacy, ease of execution, and usually (presumably) reliable indications, has been much used by chemists. It has naturally been severely criticised,[2] and by some it is rejected as valueless. Others, however, rely upon it implicitly, while others, probably the majority of those who have made a study of the value of the different methods of water analysis, consider it of value as giving information regarding a water, but rely upon it only to a limited extent, *i.e.*, they consider the probabilities as against a water condemned by this process, but they do not believe that a water is necessarily good when it appears to be so, so far as this process gives any indications.[3]

Nitrogen Important.—The determination of the amounts of nitrogen in these forms, whatever may be the imperfections of the methods employed or of the conclusions which may be drawn, is of the highest importance in deciding on the sanitary value of a water.

Nitrates and Nitrites.—Nitrogen in the form of nitrites is comparatively infrequent in water. It represents the transition state between ammonia and albuminoid compounds and the nitrates. Its presence, even in small quantities, is usually regarded as a bad indication. Nitrogen as nitrates is a common constituent of waters.

Value of Test for Nitrates, etc.—Some consider the determination of this form of nitrogen as useless, for the following reasons:

1. It is in itself harmless.

Water of unquestionable purity may contain nitrates, *e.g.*, rain, especially when its fall is accompanied by electrical phenomena, as well as water from certain formations (notably the chalk formation in England) contains considerable quantities of nitrates.

[1] Journal London Chemical Society, xx., 445.

[2] Frankland, Journal London Chemical Society, xxi., 79, xxix., 847; Tidy, ibid., xxxv., 61, 96, etc.

[3] Ekin, Potable Water, p. 9. London, 1880. Vide the writer's results on a well water of New York City, p. 432.

2. The development of water plants, etc., in the water, abstracts or destroys nitrates.[1]

3. Sewage ordinarily contains little or no nitrogen as nitrates.

As before stated, nitrates and nitrites are to all appearances produced by the action of certain ferments in the soil, and hence, unless a water charged with nitrogenous organic substances has percolated through the soil, or has otherwise been brought in contact with it, those substances may not be present. On the other hand, comparatively large amounts of nitrates in sources of supply where much or all of the water must have reached the spot by percolation, is undoubted evidence of what is termed "previous sewage contamination."[2] Some allowance may have to be made in certain cases for the passage of a water through a stratum known to contain nitrates, but most formations do not contain them. The average amount of nitrogen as nitrates and nitrites in the sixty-six samples of deep well water from the chalk formation, which affords the most, analyzed by the Rivers Pollution Commission,[3] was 0.61 part per 100,000. It has been remarked that the nitrates and nitrites are principally furnished by the decomposition of organic animal matters, vegetable matters yielding none or mere traces.[4]

As we cannot be sure that the process of decomposition has proceeded so far that no danger is to be apprehended, the presence of considerable amounts of nitrogen as nitrates and nitrites is to be regarded as a suspicious sign.

Professor Mallet's report on the chemical methods for the determination of organic matter in potable water (already referred to), shows (in connection with the determination of nitrates and nitrites) "a very obvious connection between the results of chemical examination and the known sanitary character of the several waters, the salts of nitrous and nitric acid being either absent, or present in but trifling amount in the water of Class I., believed to be wholesome; almost universally present, and in many cases in large quantities, in the pernicious waters of Class II., and very variable as to presence and quality in the waters grouped together under the doubtful head of Class III. No aspect in which I have compared together the good and bad natural waters has afforded so definite a result as this." Accordingly, under "general conclusions" we also find, "6. With the facts of this investigation before me, I am inclined to attach special and very great importance to a careful determination of the nitrites and nitrates in water to be used for drinking."

Reporting Nitrates, etc.—The mode of reporting results obtained in this determination is varied by different chemists, and the same results may be reached and different figures given. The report may be: 1, nitrogen (N) in nitrates and nitrites, separately or together; 2, nitric acid (HNO_3), nitrous acid HNO_2. Some also report "nitrates" meaning HNO_3, and "nitrites" meaning HNO_2. 3, nitric anhydride (N_2O_5), sometimes incorrectly called "nitric acid" or "nitrates," and nitrous anhydride (N_2O_3), in the same way incorrectly termed "nitrous acid" or nitrites.

Since 14 parts of nitrogen N are equivalent to 63 parts of nitric acid (HNO_3) and 47 parts nitrous acid (HNO_2), or 54 parts nitric anhydride (N_2O_5) and 38 parts nitrous anhydride (N_2O_3), very different figures from different analysts may mean essentially the same thing.

[1] Vide Wanklyn, Water Anal., Fifth edition, p. 83.
[2] Frankland, Water Analysis, p. 28; Sixth Report, p. 12.
[3] Sixth Report, pp. 100, 101.
[4] Ibid, p. 13; Ekin, Potable Water, p. 10.

Chlorine in Chlorides.—Sewage always contains considerable amounts of chlorides. A determination of the amount of chlorine in a water is therefore of value.

Since water naturally contains chlorides, sometimes much, as in cases of certain strata, proximity to the sea, etc., only the presence of more chlorine than normally exists in a water is sufficient ground for a suspicion of sewage contamination. An increase of 1 part per 100,000 may be regarded as indicating sewage pollution.[1] As an analyst may often be ignorant of the normal amount for any given water, he may be misled by this test. It is, however, of value as confirmatory evidence, or as an indication of the desirability of a more extended examination.[2] A water may be contaminated with vegetable matter, without any appreciable increase in the amounts of chlorides.[3]

Hardness.—By "hardness" is meant really the soap-destroying power of a water. Lime salts, which form insoluble compounds with the fatty acids of soap, are the chief cause of this phenomenon, though compounds of magnesia, iron, etc., may contribute to the hardness of a water. Two kinds of hardness are recognized: 1. "Temporary," which is caused by the presence in the water of earthy oxides or carbonates held in solution by carbonic acid. On boiling the water, the carbonic acid may be expelled, and these compounds separate in solid form, being removable by subsidence or filtration. 2. "Permanent," caused by the same earths in such combinations that they are not removed by boiling—sulphates, chlorides, etc., chiefly the first named. The temporary and permanent hardness together constitute "total hardness;" where distinctions are not made in a report, total hardness is meant. To express the hardness in some tangible form the custom in this country and England is to give the results in the corresponding amounts of carbonate of lime, *i.e.*, to report in effect that a certain quantity in the water destroys as much soap as would be destroyed by so and so much carbonate of lime.

Degrees of "Hardness."—The English "degrees" of hardness mean the equivalent of so and so many grains of calcium carbonates per gallon (parts in 70,000). In a few instances chemists report "degrees" of hardness in a similar way, meaning the equivalent of grains of calcium carbonate in the U. S. gallon (parts in 58,318 or 58,372). It is also frequently reported as parts in 100,000, or parts in one million. The French "degrees" signify the equivalent of parts of carbonate per 100,000, while the German degrees signify the equivalent of parts of lime per 100,000.

Sewage is quite hard, being especially high in permanent hardness. The test for hardness, though having a great economic importance (in washing, manufacturing, etc.), also has a similar bearing with the chlorine test, *i.e.*, abnormal hardness in a water justifies a suspicion of sewage contamination in the absence of other possible causes for it, and a further investigation is desirable.

Phosphates.—Sewage contains considerable amounts of phosphates, but in presence of lime and earth oxides (if the water contains alkaline or earthy carbonates, as is usually the case) only very small amounts can be detected in a water.[4] The presence of phosphates is asserted by some chemists to be always a bad indication.[5] In some cases, however, they might be derived from the rocks through which the water has passed. The amount is necessarily so small that usually only a qualitative test is made.

[1] Nichols, p 33.
[2] Fischer, Chem. Techn. des Wassers, p. 105; Wanklyn, Water Analysis, 5th ed., pp. 15 and 16.
[3] Wanklyn, loc. cit., also p. 41.
[4] Wanklyn, Water Analysis, p. 99.
[5] Phipson, Chem. News, xl., 1.

Temperature.—The temperature of a water, to be of any service in judging of its quality, must of course be taken at the source of supply. If the temperature of a source is high (70° Fahr. or more), the water is flat and unpalatable, possibly unwholesome on that account. Such temperatures also favor the development of organisms which may be prejudicial to the quality of the water.

Appearance, Color, etc.—The appearance, color, etc., of a water should be such as to commend it to the palate. The natural color of a pure water is light bluish, but impurities may modify that tint very much. Tidy[1] recommends the use of the test in conjunction with others, asserting that the peculiar tint is an indication of the *kind*, and the tint-depth an indication of the *quantity* of organic matter present. This view of the matter is regarded as "sentimental" by some other authorities.[2] So far as the experience of the writer goes, no correspondence seems to exist between the color and the quality of a water. The tests are usually made with what is known as the "two-foot tube," a colorless glass tube two feet long and about two inches in diameter, with plates of glass cemented on either end, which is filled with the water to be examined.

Odor.—Good water should have no perceptible odor or taste, either when taken from its source or after standing for any length of time. The development of an odor or taste on standing is of itself extremely suspicious. Waters, especially public supplies, at times are temporarily affected by the development in them of an unpleasant odor and taste, which, however, does not seem to render them dangerous to health. Such occurrences have been usually attributed to some peculiar condition of the algæ in the water.

Standards of Purity.—Several investigators of this subject have laid down certain standards of purity, or limits beyond which a water must be regarded as contaminated, while within them a water is considered as pure. On the part of others, strong objections are raised to the adoption of any such "hard and fast" lines.[3] The source and history of a water, its surroundings and the general character of pure waters in the district where they occur, should be taken into account.

The standards fixed by different authorities may be roughly summarized as follows per 100,000 parts:

Total solids	30 to 50 parts.
Nitrogen as nitrates	0.1 to 0.7 part.

Nitrites and ammonia, when they can be detected without concentration of the water, are regarded as indicating an impure water.

Hardness	15 to 22.5

The limits for chlorine, as may be imagined, vary very much with the locality; over five parts is regarded as suspicious in most districts.

Wanklyn (fifth edition, p. 68) gives the following classification and limits for albuminoid ammonia in water:

1. Extraordinary purity	0 to 0.005	part.
2. Satisfactory	0.005 to 0.010	"
3. Dirty	over 0.010	"

Tests made with potassium permanganate yield such different results

[1] Jour. Lond. Chem. Soc., xxxv., 84.
[2] Frankland, Chem. News, xxxix., p. 69; R. Angus Smith, Chem. News, June, 1869.
[3] Mallet, loc. cit., General Conclusions, No. 3; Nichols, p. 40.

when the conditions are so varied by different chemists—alkaline or acid solutions, hot or ordinary temperatures, excess of permanganate or not—that the standards given by different authorities would be of little use here. Some German chemists multiply the amount of oxygen absorbed from the permanganate by 20, and call the figure "organic matter."[1] Over 0.2 part absorbed oxygen is the usual limit, though some allow more. The limits suggested by Frankland and Tidy for the processes which they have respectively investigated and described are:

	Frankland. Sum of organic elements, Carbon and Nitrogen.		Tidy. Oxygen absorbed from Permanganate.	
	Upland waters.	Other waters.	Upland waters.	Other waters.
I. Great org. purity	0. to 0.2	0. to 0.1	0. to 0.1	0. to 0.05
II. Medium purity	0.2 " 0.4	0.1 " 0.2	0.1 " 0.3	0.05 " 0.15
III. Doubtful.....	0.4 " 0.6	0.2 " 0.4	0.3 " 0.4	0.15 " 0.21
IV. Impure	over 0.6	over 0.4	over 0.4	over 0.21

Several cases have been recorded where the standard limits mentioned have not been reached, and waters have been polluted to a sufficient extent to cause disease.

Local standards may be established more safely than such general ones, since the pure waters of a given district have usually the same general characters. In the case of a suspected well it is advisable to have an analysis of a neighboring well known to be pure, or at least presumably so, for comparison.

The necessity for obtaining all the information possible about a water, as well as the results of the chemical examination, is clearly of the greatest importance in deciding upon the safety of any particular supply. As a rule, too much is expected of chemists to whom water may be sent for analysis, and too little is done by those interested most in the matter, in the way of careful examination of the surroundings of their sources of water supply.

Professor Church gives an account of a well in a small English town which suddenly dried up without apparent cause. An investigation showed that a neighbor had had a water-closet close by, but had taken it out, and had substituted an earth closet, thereby cutting off the supply from the well.[2] The case seems an extreme one, but numbers of cases almost as bad are to be found on record.

In connection with these remarks it may be of interest to present analyses of some waters, etc., which have been accused, on very good grounds, of having transmitted or caused disease. The evidence with regard to some cannot be looked upon as absolutely conclusive, and indeed, with regard to almost all, some caution is used with those describing the sources and their surroundings, in asserting that these waters were positively the sole and only source of the contagion, though the evidence points very strongly in that direction.

It is noticeable that in some of these cases the chemical analysis, interpreted according to some of the standards quoted, failed to indicate contamination.

[1] Fischer, Chem. Techn. des Wassers, p. 139.
[2] Plain Words about Water. London, 1877.

Analyses of Drinking-Waters which have communicated or produced (?) Disease. (*Results in parts per* 100,000.)

	Typhoid Fever.							Cholera.	Remittent Fever.		
	1	2	3	4	5	6	7	8	9	10	11
Number of cases			8	12	39	339		609			26
Supply	Well	Well	Well	Well	Well	Brook	Well	Well	Cistern	Cistern	Ice
Analyst	R. Haines.	R. Haines.	Nichols.		T. M. Morgan.	Sargent.	Waller.	Powell.	Smart.	Smart.	Nichols.
Chlorine	3.7	3.4	3.3	1.00	32.66	128.80	much	15.131			
Phosphoric acid								trace			
Nitrogen in nitrates	2.8	3.7			2.6			very much			
Nitrogen in nitrites	0.137	0.046									
Free ammonia	0.001	0.0058	0.001	0.003		0.20	0.0004				0.0208
Albuminoid ammonia	0.008	0.014	0.013	0.013		0.26	0.0066		0.07	0.035	0.0704
Organic carbon					0.2						
Oxygen absorbed [1]					0.0186					1.199	
Hardness	much	much						[2] 33.340			
Organic and volatile				0.7		121.50 (?)		6.793			5.72
Total solids	43.6	40.0	20.3	5.0	137.8	193.00		151.333			13.52

[1] Tidy's test. [2] Lime.

References and Notes to Preceding Table.

Nos. 1 *and* 2, *Germantown, Pa.*—From the same well. Taken nine days apart, during the prevalence of the epidemic. The "total solids" recorded under No. 1, was from still another sample. A child living some distance from the place drank some of the water and sickened in consequence, otherwise the cases were among those living in the neighborhood and using the water. Well, ten feet from a brick sewer, which was somewhat choked at that point.—*Chemical News*, xliii., 183.

No. 3, *Fairhaven, Mass.*—First case, September 30th; second case, October 3d; third case, October 6th; fourth and fifth cases, October 7th; sixth case, October 8th; seventh case, October 9th; eighth, mild case, middle of October.

The entire family. No others took the disease except the nurse and her mother who nursed her. Neither of them drank any of the water. Well, one hundred feet from privy vault. Connection between the two proved by throwing salt into the privy vault and finding an increase in the chlorides in the well a few days later.—"Massachusetts State Board of Health Report for 1879," Supp., p. 270.

No. 4, *Scituate, Mass.*—Examination made about a month after the disease prevailed in the family and among neighbors who drank the water. None of the cases fatal. Only three other cases (a mile away) in the town previous to the outbreak at this spot. Well, thirty feet from privy. Water contained bacteria and infusoria.—"Massachusetts State Board of Health Report for 1879," Supp., p. 273.

No. 5, *Grouville, Island of Jersey.*—Female Orphans' Home. House isolated. Well, sixty feet from an old cesspool used only for urine and soapsuds at the time of the outbreak. Disease apparently generated *de novo*. No new cases occurred after the pump was removed.—*Chemical News*, xl., 97.

No. 6, *Eagley, near Bolton, England.*—Brook received the excreta of operatives at a factory, among which one man had typhoid fever. Water said to have been used *only to wash* the milk cans. No one affected except those who drank the milk from this dairy.—"Massachusetts State Board of Health Report for 1877," p. 123.

No. 7, *New York, Manhattan Island—Asylum.*—Well over one hundred feet deep. No ostensible cause for the appearance of the disease, except communication through the drinking-water. Sewage appeared to reach the well in about two hours from the time of deposition in the sewer. Connection between sewer and well proved by application of the "lithia test."

No. 8, *Broad St., St. James Parish, London, England*, 1854.—The number of cases is unknown; 609 deaths are believed to have resulted directly or indirectly from drinking the water of this well. Of two factories situated side by side, the workmen in one drank the water and were almost all attacked, while in the other, other water was drunk and the workmen escaped. An old lady, living entirely outside of the affected district, drank the water, as did also her niece living with her, and both died of the disease. No one else in their immediate neighborhood was attacked. The well was closed up at the time, but opened a year after the outbreak and pumped out, after which this sample was taken.—"Sixth Report Rivers Pollution Commission," p. 497.

No. 9, *New Orleans, La.*—Odor of the water, like swamp water. Cistern (wooden), old and rotten.—"Report on the Water Supply of New Orleans and Mobile. Dr. Chas. Smart. National Board of Health Bulletin," vol. i., 317.

No. 10, *Mobile, Ala.*—Case similar to the last. With regard to this, Dr. Smart notes particularly that the fever "prevailed in the absence of prominent sources of malarial exhalation to account for the presence of the disease."—"National Board of Health Bulletin," i., 317.

No. 11, *Rye Beach, Mass.*—Digestive disturbance caused, "characterized by a sensation of giddiness and nausea, vomiting, diarrhœa, severe abdominal pain, all of which was accompanied by fever, loss of appetite, continued indigestion, and mental depression." Ice taken from a shallow pond choked with marsh mud and decomposing sawdust, and used in the hotel where all the cases occurred.—"Massachusetts State Board of Health Report for 1876," p. 467.

THE CHARACTERS AND DISTRIBUTION OF AMERICAN SOILS.

By N. L. BRITTON, PH.D.

The soil is generally understood to be the upper, superficial portions of the accumulations of loosely consolidated materials, which in most regions form the surface of the earth. In this chapter it will be so considered. It is the part of the earth's crust which, directly or indirectly, supports vegetable and animal life, and is thus of immense importance to mankind. The thickness of this superficial material varies greatly in different localities; in some we find very little, or, indeed, none at all, the rocks coming directly to the surface; but such are limited in area and mostly confined to the slopes and summits of mountains; nearly everywhere there is an appreciable quantity of soil, and the accumulations are occasionally over one hundred feet deep.

To render what follows intelligible to all, it has been deemed advisable to preface this dissertation with some of the leading facts relating to the origin, structure, and constituents of soils in general.

Structure and Composition.

The soil is constituted of variously sized fragments of mineral and organic matters, and its character depends on the relative abundance of the different constituents, the dimensions of the fragments, and their greater or lesser consolidation. It is invariably permeated to some extent by water and air, and the quantity of these fluids depends on the permeability and the absorbing property of the soil, which vary greatly. The size of the component fragments is very variable, and ranges from microscopical particles, which make up the greater part of the mass, to boulders of huge proportions.

Mineralogically considered, it consists primarily of sand and clay; these constituents occur either alone or intermingled with each other in various proportions; they are often accompanied by pebbles, or even large stones of different kinds of rock, and generally by small amounts of other inorganic or organic matters. Most of the latter is derived from plants and is known as peat, humus, etc. Clay and sand are, however, the bases of all soils, and one of these minerals is always present.

Origin of Soils.

All soils have been derived from previously existing rocks by processes of decay and disintegration acting through immensely long periods of time, and are still forming wherever rock masses are exposed to agents which produce and forward these changes. The materials resulting from

ing of these enormous ice-sheets was accompanied by a great flow of water, which further distributed the rocks, clay and sand, and effected a partial sorting of the materials, concentrating fragments of similar sizes and same specific gravity. Thus were formed the deposits of fine and coarse gravels, sands, and "boulder-clays" found within the glaciated areas, and a large part of the soils of these portions of North America were deposited in this manner.

Within the area of this "Glacial Drift" all varieties of soil are found, as the manner of their production would lead us to expect, and radically differing kinds are found within a few feet of each other. The drift, or *till*, as it is sometimes designated, varies in amount, however, in different districts; in many localities it is only a slight covering, and here the decomposition of underlying rock has originated much of the soil.

(c) *Air.*—We may add atmospheric currents to these two most important distributing agents. Their action is appreciable only on very light, readily movable soils, and is limited in extent and importance.

Soils Considered with Regard to their Mineralogical Compositions.

Any attempt at classifying our soils under this consideration must at best be but imperfect, as it is difficult to draw the lines between the divisions which have to be adopted. A soil which is placed under one category in certain parts of the country, is considered as belonging to another in other sections; this difficulty is due to their relative abundance in the various districts. It has been thought desirable, however, to present the following classes, as in some respects the divisions here made are simpler and more apparent than in describing them according to their origin, this being often somewhat obscure, although from a strictly scientific standpoint the more satisfactory.

The three most important and widely spread classes of soil as here limited are as follows:—*Sandy Soils*, *Clayey Soils*, and *Loams*.

(a) *Sandy Soils.*—These are here regarded as consisting of seventy-five per cent. or more of quartz sand (silica). They are found throughout the country, and are generally healthful and desirable for building sites, as they have a free and ready natural drainage, and are only to be avoided when low-lying and saturated with water or organic matter, or when immediately underlain by impervious strata, forming basins in which water is retained. Such a geological structure causes permanent saturation of parts of the soil, and is often productive of malarial troubles. It is therefore advisable to examine the underlying strata.

(b) *Clayey Soils.*—Under this division we here include all soils consisting of seventy-five per cent. of clay (alumina silicates) or a higher percentage. They are widely spread all over the country, and are wet, cold, impervious materials, and hence undesirable, unless the inclination of the strata is sufficient to afford good surface drainage. Clays are generally to be regarded with suspicion.

(c) *Loamy Soils.*—These vary greatly in composition, being made up of variable amounts of clay and sand, either of these constituents reaching seventy-five per cent., as the class is here limited. Those approaching the extreme limits of this definition are known as Clayey Loams and Sandy Loams. Only the varieties consisting very largely of clay are to be avoided, and, generally speaking, all that has been said about sandy soils is applica-

ble to loams as well. They are perhaps our most abundant soils, and are nearly everywhere common.

To these three principal classes of soils the following, less abundant ones, may be added.

(d) *Stony or Gravelly Soils.*—These are local in distribution. Their natural drainage is excellent, and they often afford very desirable sites for habitations.

(e) *Calcareous Soils*, are loams or sands somewhat impregnated with carbonate of lime. The amount of this substance present varies considerably, sometimes, but rarely reaching fifty per cent., and ranging downward to five per cent., under which percentage the soil is not noticeably calcareous. They occur only in limestone or marble regions, and are generally found wherever these rocks approach the surface, being the result of their disintegration. Calcareous soils are distinguished from others by carrying "hard" waters, this character being due to the presence of carbonate of lime in solution. This is not necessarily an injurious feature, and these soils may be perfectly salubrious.

(f) *Magnesian Soils*, result from the decay of serpentines, talcose or chlorite schists or other rocks principally composed of magnesian minerals; they are permeable, and not to be regarded as objectionable. Their only bad feature lies in the large quantities of magnesian salts carried by the waters coming from them. These soils are only occasionally met with.

(g) *Highly Ferruginous Soils.*—These overlie deposits of bog-iron ore, and are very local. Their salubrity has been questioned, and malarial troubles ascribed to their proximity in certain foreign localities. We have heard of no such experience in this country.

(h) *Soils of Mud or Peat.*—These are confined to low grounds and are essentially marsh soils; they will be more fully discussed under that heading. They consist of loams or clays, saturated with water and highly impregnated with decaying vegetable matter, the latter substance frequently making up one-half of the soil, or even more. True peat appears to be non-malarial, but all these wet, mucky soils are probably dangerous in other ways, and it is safer to avoid them.

(i) *Soils of Humus and Mold*, result from abundant vegetable growth in comparatively dry situations, and are the natural soils of forests, where the accumulations are derived from the leaves and twigs of trees and shrubs; and of prairies, where they form from grasses and other herbs. These soils are strictly superficial, seldom extending more than a foot in depth, while peat may be fifty feet in thickness.

Soils Considered with Regard to their Origin.

Considered from this point of view, we may divide our soils into two quite well-marked classes, viz. :—*Transported Soils* and *Indigenous Soils.*

A.—Transported Soils.

We have already briefly alluded to this class in discussing the methods by which soil-forming materials have been produced and the agencies whereby they have been distributed. These soils have been brought to their present positions from other places, and generally have little in common with the underlying rocks. We will successively discuss the different varieties which fall under this heading.

(a) *Soils of Glacial Drift.*—These consist of unassorted deposits of clay, sand, gravel and boulders brought from the north by the ice-sheets of th Glacial Epoch; and are found throughout the areas traversed by them In some localities the deposits show signs of stratification, but generally this structure is absent. The surface of the country over which they are found is generally sufficiently diversified by the uneven thickness of the accumulations, and by irregularities of the strata on which they rest, to afford free drainage in some direction, and unless excess of clay renders them impervious, desirable building sites, from a sanitary standpoint, can generally be selected. Unfortunately, however, this latter condition sometimes occurs, and the clay interferes seriously with drainage. This is especially true in certain localities along the southern margin of this drift on the Atlantic sea-board, where the conformation of the surface of the "terminal moraine" is such that swamps and stagnant ponds are numerous, the non-porous soil retaining water in hollows often surrounded by much higher ground, although many feet above tide-level. Here relief is only obtained by extensive, and therefore expensive systems of artificial drainage, and must sooner or later be adopted in all thickly populated districts where such conditions prevail.

From what has already been said of the boundaries of the Glacial Drift, its geographical distribution will be apparent.

(b) *Soils of Stratified Drift*, differ from the Glacial Drift soils in having a well-marked stratified structure, the clay, sand, and gravel composing them being arranged in successive layers, which are usually readily distinguishable from one another. In many districts they occur with the other class of drift soils, and were deposited from the currents of water and the lakes which accompanied the melting of the glaciers; they occur also in non-glaciated regions. When mostly composed of sand or gravel, these soils are perhaps the most salubrious of all, combining a perfect natural drainage by percolation, with great capacity for retaining heat, and freedom from organic matter. When principally composed of clay they are to be avoided.

Perhaps the most notable of these soils are those forming the so-called "Yellow Drift," from its predominating color. This is found in isolated patches along the southern coast of New England, over nearly the whole extent of Long Island except its extreme western parts, and thence extending southwardly, composing nearly all the soils of Southern New Jersey, and of Delaware and Eastern Virginia; it is traceable even to Florida, along the Atlantic sea-board. The salubrity of these districts has rendered them famous. Much of the territory is covered by pine forests, popularly known as the "pine barrens," and these are well known to be non-malarial in a great many localities. This is undoubtedly largely due to the character of the "Yellow Drift" soil, composed almost exclusively of sand and gravel. These deposits have a greater antiquity than those of the Glacial Drift, and were deposited at a period when a large part of eastern North America was submerged. They are therefore also known as the "Pre-Glacial Drift." Most of our celebrated sea-side "Health Resorts" are situated on these soils, and this is probably the most potent cause of the salubrity of these places, which are found from Montauk Point southward.

In speaking of sandy soils, we have alluded to the danger in those underlain by beds of clay. This is particularly applicable to these soils of stratified sand and gravel, and should be taken into account in the selection of building sites.

(c) *The Flood-plains of Rivers, Terraces, etc.*—Rivers carry large quantities of solid matter, held in suspension by the water. When the rapidity of their flow becomes lessened by the expansion of the valley, or a decrease in the amount of slope, much of this fine silt, which is mostly clay, falls to the bottom and these valley-deposits are formed. The flood-plains occupying territory only slightly elevated above the level of the stream, form particularly dangerous soils; the impermeability of the clayey material, and the nearly level surface of the deposit, render the natural drainage very bad, and these soils, although rich and attractive to the farmer, are almost invariably malarial. River terraces are produced by the stream cutting through such deposits to gain a lower level, and we often find a number of these in crossing a valley, each marking a former level of the water. Being more elevated than the flood-plains they are more desirable, but the impervious nature of the deposit is still a bad feature.

Lake terraces owe their origin to a similar cause, and are formed of similar materials. They are particularly noticeable around the Great Lakes, and were deposited when the level of the water stood higher than at present. They contain more sand and gravel than river terraces, and are less objectionable.

(d) *Marsh Soils* consist of clay or sand, mixed with variable amounts of decaying organic matter, the result of vegetable growth, which often constitutes more than one-half of the mass, and this mixture is saturated with water. Hence these soils are partly composed of transported, and partly of indigenous material. Unless thoroughly drained, marsh lands are very dangerous, being almost always malarial, although there are some exceptions to this statement. The growth of our large cities is, however, so rapid, that extensive tracts of this character become unavoidably occupied by habitations, and malarious sections of them can often be traced to this cause. Complete drainage at the outset is the only means of preventing this trouble. Unhappily, this precaution is too seldom observed. To be perfect and permanently valuable, the drain conduits should be placed low enough to rid not only the surface of water, but also the soil itself.

Marshes are found to some extent in all sections of the country, but their greatest development is along the coasts of the Atlantic Ocean and the Gulf. The largest are the Dismal Swamp of Virginia, and the Everglades in Florida. Brackish swamps are popularly known as "salt meadows."

Marsh soils which are composed for the greater part of true *peat*, produced by the abundant growth and partial, slow decay of moisture-loving plants, particularly the *Sphagnum* mosses, are apparently free from malarial troubles. These "peat bogs" are often many feet in thickness. They are indigenous rather than transported soils, but from other relations are best here considered. The cause of this freedom from malaria is hitherto unexplained, though it may be produced by the antiseptic action of the organic acids in the peat.

Such deposits occur in limited areas in many parts of the United States, but with us never occupy the extent of territory covered by them in certain parts of the Old World, as Ireland, Central Germany, and Scandinavia in particular. In Great Britain they are known as "moors" or "heaths," and in America these are found only in Newfoundland, Labrador, etc.

The marine alluvium forming our salt meadows, composed of the decaying remains of certain grasses and rushes, mixed with a small percentage of silt, also seems non-malarial when undisturbed, perhaps from a

similar cause to that above suggested. These "meadows" are found along the coasts, wherever land is occasionally flooded by salt water.

(e) *Alkaline Soils.*—So much of the Far West is covered by alkaline plains that they here deserve notice. The soil is generally a light loam, sometimes clayey or sandy, containing but a limited amount of organic matter, but saturated with sulphates, carbonates, or chlorides of soda, potash, magnesia, and lime. These salts render the waters which they carry intensely purgative, and almost useless for domestic or manufacturing purposes. Little is known regarding the salubrity of these soils, but the fact that good water must either be pumped from a very great depth or transported long distances, renders their occupation improbable except in favored localities. Another unfavorable feature is experienced in the clouds of alkali dust blown about by the winds.

Geographically, alkaline soils are mostly restricted in the United States to the Great Basin—the valley lying between the Rocky Mountains and the Sierra Nevada. They extend over portions of Idaho, Utah, Wyoming, Nevada, Arizona, and New Mexico, and occupy regions formerly covered by extensive inland seas, which have now been mostly drained away by the cutting down of the river channels. The Great Salt Lake of Utah and other smaller bodies of alkaline water still remain.

(f) *The Sea-shore Sands.*—These form important soils, as they are uniformly healthful; and although for many reasons they are seldom selected for permanent habitations, their salubrity is unquestionable.

(g) *Artificial Soils.*—Under this heading we here include all deposits produced by artificially filling in low grounds. In laying out towns and villages, and the subsequent construction of streets and buildings, it generally becomes expedient to bring the surface of the ground to a certain degree of uniformity by removing the tops of hills and filling up the depressions, which are often marshy. This practice becomes particularly necessary in large cities, where land is very valuable. The objects generally sought by "filling in" are twofold: *First*, bringing the surface to a desirable grade; *second*, depositing material on a swampy place to "dry it up," and thus escape the expense of properly draining it. The latter object is usually only apparently attained, and is always done with the very great risk of producing subsequent sickness. The great mortality in certain sections of our cities is often directly traceable to mistakes made in preparing the soil for building, by this obnoxious practice, which cannot be too strongly condemned.

The areas of former swamps, and the channels of former streams, now covered up, are apparent in the relative health of people residing on ground formerly occupied by them, and that of the inhabitants of districts originally dry. All such places should be thoroughly drained before grading and building are begun, and the authorities should insist that these precautions be taken.

If it were not for the decidedly objectionable character of the filling generally employed, such soil might be less dangerous; but all kinds of waste matter and rubbish get mingled with the dirt, and a very unhealthy soil is the result. Besides this consideration, the mere filling up of a wet hollow does not effect any real drying or drainage, but rather lessens the possibility of the stagnant waters disappearing by evaporation; for the dirt becomes saturated with water, and this mixing with the organic portions produces a wet, nasty, almost invariably malarial soil, with no chance of effective drainage.

We do not protest against filling a naturally dry depression with a nat-

CLIMATOLOGY AND METEOROLOGY.

BY J. G. RICHARDSON, M.D.,

Professor of Hygiene in the University of Pennsylvania.

CLIMATOLOGY.

THE problem of furnishing a proper definition of Climate, abandoned as hopeless by Dr. Parkes in the body of this work, is to a certain extent solved by Prof. Loomis, in his excellent treatise on Meteorology, by the following description of what it is, and depends upon. "By the climate of a country we understand its condition relative to all those atmospheric phenomena which influence organized beings. Climate depends upon the mean temperature of the year; upon that of each month and each day; upon the maximum and minimum temperatures; upon the frequency and suddenness of the atmospheric changes; upon the transparency of the atmosphere and the amount of solar radiation; upon the moisture of the air and earth; upon the prevalence of fogs and dew; the amount of rain and snow; the frequency of thunder-storms and hail; the direction, force, and dryness of the winds, etc. All these particulars can only be determined by long-continued and careful observations."

The magnificent basis for a comprehensive system of American Climatology which is being rapidly laid, by the diligent observations in all parts of the country of our Signal Service Bureau, will doubtless afford us in the near future most important practical results; but as yet the chief triumphs of this valuable department have been gained in the science of meteorology, under which head they will be considered more in detail.

The study of climate has been especially aided in America by the observations tabulated in the admirable Isothermic maps (pp. 463, 464) for which we are so much indebted both to the Smithsonian Institution and to the United States Signal Office. The subject appears therefore to require a more detailed exposition than that given in the body of this book.

As Baron Humboldt in his "Cosmos" remarks, "If the surface of the earth consisted of one and the same homogeneous fluid mass, or of strata of rock having the same color, smoothness, density, and power of absorbing heat from the solar rays, and of radiating it in a similar manner through the atmosphere, the isothermal, isotheral, and isochimenal lines would all be parallel to the equator. In this hypothetical condition of the earth's surface the power of absorbing and emitting heat would everywhere be the same in the same latitudes."

But as such is by no means the case, we find an infinite variety of temperature, humidity, and amount of rainfall existing at places upon the earth's surface at the same distance from the equator. Hence places having exactly the same latitude may possess widely different climates.

are anxious to secure the potent remedial effects of removal to a more suitable climate.

In the United States the hottest portion is the southern end of Florida, and next to this rank Southern Texas, and Southwestern Arizona. The mean annual temperature of the whole country is not far from 53° F. The areas of territory having a mean annual temperature above 55°, comprise the entire cotton region, those above 70° the sugar and rice regions, and between 50° and 60° is included most of the tobacco region. As may be seen by consulting the accompanying Isothermic maps (pp. 463, 464), the cotton-growing sections lie between the Isotherms for July (the hottest month), of 75° and 85°, the winter limit of the cotton region being that of the Isotherm of 35° for January nearly. The regions ranging between 75° and 85°, average July temperature, appear to include all those portions which are liable to epidemics of yellow fever.

The coldest regions are found in the northern part of New England, Northern Michigan, Wisconsin, and Minnesota, and the high mountain region of the Cordilleras.

On the whole Atlantic coast from Penobscot Bay to the mouth of the Rio Grande, and the whole coast of the great lakes, besides a considerable portion of the Pacific coast, the highest observed temperatures range from 95° to 100°. The Atlantic plain stretching from the eastern base of the Appalachian system of mountains to the neighborhood of the coast, and nearly all of the Mississippi Valley, range in their highest summer temperature between 100° and 105°. This difference is, of course, due to the absence of any cooling influence from the Atlantic sea breezes.

The highest maximum temperature is reported from Southwestern Arizona, and from Southwestern California, where the thermometer is said to have registered 135° in the shade. The average maximum on the Pacific coast is lower than on the Atlantic coast, ranging between 90° and 100°, but at some distance inland in the great valley of California the elevated temperatures mentioned are met with.

The distribution of population in accordance with mean annual temperature, throughout the wide domain of our Union, is a question of much interest, and valuable light has been thrown upon it by recent bulletins from the Census office.

According to these Government statistics, it appears that ninety-eight per cent. of the total population of the United States reside in regions the mean annual temperatures of which range between 40° and 70° F.; eighty-two per cent. dwell in sections which have a mean annual temperature of 60° or under; sixty-nine per cent. in regions where the temperature is at or below an average of 55°; and thirty-eight per cent. inhabit portions of the country the highest mean annual temperature of which is 50°. From the same source we also learn that ninety-seven per cent. of our fellow-countrymen are exposed to summer heats which have a range of 20° only, lying between the mean temperatures for July of 65° and 85° F. This leaves a scattering fringe of population of only three per cent. outside of these limits, who suffer a more intense average heat or cold.

The brief but interesting statements of Professor Parkes in the text of this work, under the section treating of the effect of lessened pressure of the air as a climatic factor, and especially in its relations to Phthisis, may be appropriately supplemented here by some account of our own health resorts, which have been especially studied by American physicians in reference to that most fatal disease upon most of death registers of the Northern States—pulmonary consumption.

name of "the Land of Flowers") are very important and valuable to the invalid.

The mean height of the barometer, for 1880, at Jacksonville was 30.108 inches. The mean temperature for the same year was 70.1°, with extremes during twelve months ranging from 99° in June, 1881, to 19° in December, 1880. The mean temperature for November, 1880, was 61.2°; for December, 52.2°; for January, 1881, 52.7°; February, 57.9°; March, 59.5°; the mean relative humidity was 71.8, and the rainfall for 1880 amounted to 65.51 inches, of which 16.25 inches fell in the month of September.

The various resorts upon the St. John's River in Florida, in the neighborhood of and southward of Enterprise, possess the advantages of an equable climate, moist warmth, abundant opportunity for outdoor life, and a good supply of small game and fresh fruits. The chief drawbacks are the deficiency of milk and of good fresh meat, and the presence of insects, reptiles, and malaria. To obtain the greatest benefit from the climate one must absolutely live in the open air, from an hour after sunrise to half an hour before sunset.

The climate of Key West, on the southern extremity of Florida, is said to be the warmest and most equable on the eastern coast of the United States. Even in January the south winds are frequently oppressive and debilitating. From five to ten "northers" occur every winter, and though they are disagreeable on account of the violent wind, they do not often reduce the temperature below 40°. Dr. D. G. Brinton ("Florida and the South") says in regard to Key West, though the proximity of the Gulf Stream renders the air very moist, mists and fogs are extremely rare, owing to the equability of the temperature; and though the hygrometer shows that the air is constantly loaded with moisture, this same equability allows the moon and stars to shine with a rare and glorious brilliancy, such as we see elsewhere on dry and elevated plateaux. Another effect of the Gulf Stream may also be noted. Every evening, shortly after sunset, a cloud bank rises along the southern horizon in massive irregular fleeces, dark below and silver gilt above by the rays of the departing sun. This is the bank of clouds over the Gulf Stream, whose vast current of heated water is rushing silently along some twelve miles distant. The mean height of the barometer at Key West for 1880 was 30.076, the mean temperature for the same year was 78.7°, with extremes during twelve months ranging from 97° in July, 1880, to 56° in March, 1881. The mean temperature for November, 1880, was 78.5°; for December, 70.1°; for January, 1881, 72.2°; for February, 70.9°; March, 70.6°, and for April, 75.0°; the mean relative humidity for 1880 was 73.4, and the rainfall for the same year only 33.41 inches, of which but 0.71 inch was precipitated in December.

Although much injury to the health is often experienced by the invalid from the malarious affections contracted in the interior of the State, the sea-coast of Florida is said to be entirely exempt from these dangerous maladies, at least during the late autumn and winter months. The humid atmosphere, which while it tends to ease cough in some instances, does appear in others to promote the softening of tubercular deposit, and the frequently crowded condition of the hotels and boarding-houses, which often compels patients affected with incipient phthisis, to hear and see the sufferings of others in the advanced stages of their own disease, are the chief drawbacks to the incontestable benefits which this charming climate affords in many instances.

The climate of the West Indies is mild and balmy, and cases of phthisis often improve for a few weeks after their arrival in Havana, Barbadoes,

temperature and comparative dryness of the atmosphere, the character of the sun's light, the freedom from all forms of paludal poison, and to other causes, the climate of Minnesota is stimulating and favorable in its effect upon diseases of the lungs and air-passages, which are dependent upon and characterized by debility, imperfect digestion and assimilation, and the tubercular or strumous diathesis. Also, that the beneficial effects of the climate are largely due to influences exerted directly or indirectly upon the functions of nutrition. And lastly, that acute lobar pneumonia is not to any great extent prevalent in Minnesota, although chronic forms of pneumonic inflammation do occur, and that the cases of phthisis originating in the State have been generally of pneumonic origin, but that this does not conflict with the fact that phthisis contracted elsewhere, and under different climatic conditions, may be benefited by influences existing in Minnesota. Dr. Staples considers this final conclusion verified, especially by observing the large number of the present inhabitants of the State, now in good health, who came from other localities as invalids, suffering from evident phthisis pulmonalis, either caseous or tuberculous; he closes with the usual caution against expecting that merely temporary residence is likely to result in permanent benefit to the consumptive.

The pure dry atmosphere of Colorado, the surpassing beauty of its natural scenery, and its great comparative accessibility, by way of the Pacific railroads, have contributed to develop this part of the eastern slope of the Rocky Mountains into a grand sanitarium for consumptives. The mean altitude of the barometer at Denver, Col., for 1880, corrected for its 5,294 feet above the level of the sea, was 29.980 inches; the mean annual temperature was 47.4°, with a range during twelve months from 95° in July, 1880, to −20°, in February, 1881; the monthly average for November, 1880, was 22°, and for December, 29.9°; the mean relative humidity was 48.4°, and the amount of rainfall 9.58 inches, precipitated as rain on thirty-eight days, and as snow on thirty-nine days during the year. Dr. Dennison, of Colorado, who has written extensively upon this subject, contends that since lessened barometric pressure, corresponding to 24 or 25 inches, has been shown to form an important factor in successful climatic treatment of phthisis, the resort to a well-chosen elevated climate should constitute part of a physician's advice to every consumptive who can follow it, and for whom the elevation is not specially contra-indicated. Dr. Dennison claims that the "favorable or positive influence of high altitudes upon the progress of consumption is best shown in the commencement of chronic inflammatory and hemorrhagic cases, and generally in fibrous phthisis in young and middle aged subjects, with little constitutional disturbance. The unfavorable or negative influence of high altitudes upon the progress of consumption is mainly seen in proportion as the disease approaches or is complicated with the following conditions, which are intensified by an irritable, nervous state, and lack of desirable will-power, aided by the stimulus and hope of youth; *i.e.*, First, cardiac disease, if associated with increased labor and abnormal activity of the heart. Second, the stage of softening in acute cases and with extensive deposit. Third, chronic third stage cases with from one-third to one-half the lung surface involved in diseased changes, if the thermometrical and other usual signs of constitutional disturbance are present in a marked degree."

It is true that in classifying, according to the two rules of Dr. Dennison just quoted, any particular patient in one or the other group, we have decided almost as much respecting the prognosis of the case, as in regard to the propriety of sending it to Denver, but as indicating with certainty

dle States, who are suffering from bronchial difficulties, incipient consumptions, hereditary or acquired, or from the nervous exhaustion of mental overwork and various other causes, and who therefore dread a long, cold, and changeable winter, the climate and health resorts of California are superior to most, and second to none in the world. He urges most emphatically, however, the eminently wise counsel that persons with organic disease of the lungs in an advanced stage, should *always* remain at home where they can have the loving attention of family and friends. The southern California Channel islands are strongly recommended as health resorts by Dr. J. P. Widney, who asserts that their peculiar merit is that while lying within the line of a semi-tropical climate, they are entirely exempt from the scourges of yellow fever, bilious remittent, and ague; and their comparatively small size, and distance from the main land save them from strong sea-breezes and coast-fogs, and secure for them a remarkably equable temperature.

The mean altitude of the barometer at Los Angeles, Cal., for the year 1880 was 30.007 inches, the mean temperature for the same year 58 4°, with a range during twelve months from a minimum of 35° in November, 1880, to a maximum of 94° in April, 1881. The average temperature of November, 1880, was 55.5°; of December, 55.3°; of January, 1881, 51.7°; of February, 57.9°; of March, 55.8°; and of April, 61.4°. The mean relative humidity for 1880 was 69.7, and the amount of rainfall 18.65 inches, all of which was precipitated in the form of rain on a total of fifty-one days during the year.

These remarks upon climate as a remedial agent, especially in pulmonary complaints, would be incomplete without a few suggestions in regard to practically utilizing such items of information in the management of phthisis. With respect to temperature, a uniform cold climate, such as that of Minnesota or Colorado, is the best for some cases; and, on the other hand, for others a change to a warm climate has appeared to accomplish all that could be desired. In deciding this branch of the question Professor A. Flint very judiciously advises that the feelings and choice of the patient should have considerable weight. If, for example, we find on inquiry that the invalid when in health habitually experienced more vigor and enjoyment in summer than in winter, removal to a warm climate would probably be best suited to his case, but if the reverse is true, a cold climate is to be preferred. Moreover the condition as regards feebleness has an important bearing upon the problem. If the patient is so feeble as not to be able to live out of doors in cold weather, or if the reaction from the impression of cold be slow and imperfect, a warm climate is more suitable. Dr. Brinton wisely suggests, in addition, that cold climates such as Minnesota, Labrador, or the Canadian highlands, are better adapted to patients who are not ordinarily subject to catarrhs, irritation of the pharynx, coughs, pneumonia, and pleurisy; are not plethoric; are free from rheumatic, neuralgic, and gouty pains, which become worse as winter approaches; whose throats are anæmic rather than congested; whose livers are torpid; and who are oppressed and enervated by heat. The danger of hemorrhage in cold and especially elevated regions has already been referred to. In some doubtful cases invaluable aid may be derived from an examination of the sputum microscopically, after liquefying by boiling with caustic soda solution according to Dr. Fenwick's method.[1]

[1] See my paper on Pulmonary Elastic Tissue in the Early Diagnosis of Phthisis: Transactions New York State Medical Society, 1872.

paper more sensitive so as to occupy a shorter period of time in making an observation would also be a great desideratum. It is well known that increased velocity of the wind may bring more ozone to a given point than if that rapidity were less. To determine the quantity of ozone likely to affect the health of an individual subjected to the influence of rapid currents of air, it is desirable to expose the test-paper to the same atmospheric current. And yet the loss of liberated iodine, to which the darkening of the paper was due, by evaporation, as an effect of just such a current, suggests that perhaps the deepest coloration of the slips of test-paper may be obtained, not when the amount of ozone is the greatest, but when the test-paper is best protected from too great velocity of wind, especially when there is an excess of moisture in the atmosphere.

Dr. Nicholson found ozone more abundant in a pine forest than in the open country during the summer, but less abundant in the winter; less abundant in coal-pits and over swamps than in the open country; and less abundant generally in the night than by day. The results of these investigations in regard to the air of pine woods are in accord with the statements of Schreiber, of Vienna, who informs us that the turpentine exhaled from pine forests possesses, to a greater degree than all other bodies, the property of converting the oxygen of the air into ozone, and by this fact it has been sought to explain why a continued residence among the balsalmic odors of the pines has long been credited with a favorable influence in cases of phthisis. Dr. Day, of Geelong, Australia, in an able paper published some years since, also sustained similar views in regard to the activity and value of turpentine as an ozonizer. The careful and systematic observations now being carried on under the auspices of Dr. H. B. Baker, the energetic Secretary of the Michigan State Board of Health, give promise of some very important additions to our knowledge of the relations between ozone and health during the next few years.

Ozone is stated by Dr. John Mulvany, in a paper contributed to the "Michigan Health Board Report for 1880," to have a marked influence upon the human procreative functions. Dr. Mulvany declares that in a very extended series of observations, carried on in all parts of the habitable globe, he has repeatedly found the births few where ozone is scanty, and numerous where it is abundant. The most positive evidence in support of this theory he obtained in Trincomalee in Ceylon. The village is low, but little above the sea-level, open to the sea on the N. E., and with the jungle on the S. W. From May to September the S. W. monsoon blows over the island, and in passing through the jungle is robbed of its ozone. From October to April the N. E. monsoon blows over the bay of Bengal, and arrives at the village laden with ozone. During April the winds veer from N. E. to S. W., and the ozone is in fair proportion. Such peculiar conditions afforded a very suitable opportunity for observing the effect of ozone on the chances of fecundation among the Ceylonese villagers, and on overhauling the baptismal register kept by the Roman Catholic priests, Dr. Mulvany found that during the S. W. monsoon, a period extending from May to September, with a relative proportion of ozone expressed by two and one-half degrees on Schönbein's scale, the conceptions were only fifty-seven per cent. of the number occurring in the period from October to April, when the amount of ozone was represented by eight degrees, or more than three times as much.

The average annual rainfall upon the surface of the United States, exclusive of Alaska, is approximately 29 inches, that for the spring and summer months is about 17 inches, and the entire range for these months is

and less strong fits of torment were felt until the evening of that day. This intense neuralgia of the 17th seems connected with the magnetic storm of the 17th, for there was no storm of barometric depression charted by the Signal Bureau within neuralgic range for that date."

In order to determine the average distance of the storm-centre at the beginning of attacks of pain in this interesting case, special observations were made on sixty well-defined storms occurring in ten consecutive months, and these showed a sphere of influence of from 200 to 1,200 miles, and an average of 680 miles. Storms coming from the Pacific coast were felt the farthest off, in fact soon after they began to descend the eastern slope of the Rocky Mountains. Those which moved along the coast from the Gulf of Mexico were associated with a neuralgia not quite so intense nor so quickly perceived. If neuralgia begin with a low or rising barometer, the ridge of depression is narrow and invariably broken down within seventy-two hours, and more frequently within twenty-four or thirty-six hours; and during this rise coincident with the pain, the difference between the wet- and dry-bulb thermometers, instead of increasing, as is usual with this barometrical condition, sometimes actually diminishes, or increases for a few hours only, and then diminishes, showing increasing humidity. When pain occurs with this instrumental condition the coming storm depression will carry on its eastern side clouds and increasing moisture and sometimes rain or snow, clear over the summit of the advancing high area pressure (high pressure area?) in front of it, holding an unusually high degree of relative humidity in the air, on the high eastern slope of the high barometer area. These are the conditions under which attacks of pain come on with the rising barometer. Its usual condition is with a falling, but it may be a high barometer, rising temperature, and increasing relative humidity.

Should the pain be on during a day of intermitting rain, the pain assumes an additional activity just before the increasing shower, and continues twenty or forty minutes; this will sometimes happen four or five times in twelve hours. Each little increment of pain seems to bear about the same relation to the showers as the main attack bears to the storm.

The protection of human life and health from the injurious action of electricity on the grand scale upon which nature displays it in thunderstorms is obviously a part of Preventive medicine, and it seems proper, therefore, to add a few words respecting it in this place. Such reference is the more appropriate here since French sanitarians devote considerable attention to the subject, and even in their elementary books for the secondary schools (into all of which the study of hygiene has been introduced by law, according to the decree of May 6, 1872) the ancient rules of our venerated Dr. Franklin are still reverently mentioned. And indeed such honors appear by no means ill-deserved when we consider that the kite-string in Franklin's memorable experiment in a field (as it was then) near Philadelphia has become the progenitor, not only of the multitude of lightning-rods which protect dwellings in every part of the civilized world, but also of the marvellous network of telegraph wires and of ocean cables which during the last half-century have so vastly modified the social and mercantile life of mankind.

The electricity of the atmosphere is the result of physical causes, such as the movement and pressure of the air, friction against the earth, differences of temperature, and chemical reactions. It is asserted by some that our planet is charged with negative, and celestial space with positive electricity, but at any rate there is little doubt that lightning is only an

struck by lightning. Hence the safest preservative means would be to occupy during thunder-storms a hammock suspended by silken cords in the middle of a large apartment." This last suggestion would of course chiefly benefit timid hysterical females, to some of whom, however, it would fully repay all the trouble involved in putting it into practice by relieving that agonizing fear of being struck by lightning, which we may assure them is totally needless when they adopt such a sure precaution against the dangers of atmospheric electricity.

METEOROLOGY.

From the time the great Dr. Johnson uttered his famous sarcasm upon observers of the weather, to wit: "A certain set of men pass their lives in observing the changes of the weather, and die at a good old age with the conviction that the weather is changeable," little has been accomplished in rendering us more truly weather-wise, until the splendid results attained by our own Signal Service Bureau gave a new impetus to the study of meteorology.

In fact, the *raison d'etre* for an attempt to supplement the information furnished by Prof. Parkes' exhaustive work in the department of meteorology must chiefly be based upon the wonderful development that science has attained through the labors of our Signal Service. And in this respect few can dispute that not only the hygienists of America, but also those of the Old World, are under great obligations to our National Government, which, taking timely advantage of opportunities never before presented in the history of mankind, has utilized them with marvellous success.

These opportunities consist, of course, in the circumstances, first, that in our American Union there is a larger portion of the earth's surface inhabited by civilized man, now under the same jurisdiction, and controlled by one central authority, than in any antecedent epoch; and, second, that by the most extended system of telegraphic communication ever organized, it has been possible, during the last decade, for the first time in the history of the world, to obtain instantaneous and simultaneous weather reports from an area of the earth's surface occupying the whole breadth of our continent, stretching from the thirtieth almost to the fiftieth parallel of latitude, and comprising more than three millions of square miles.

Over this vast section of country signal stations have been established, under the direction of the Weather Bureau, at least wherever practicable, and to such an extent as the yearly appropriation would permit. At these stations three observations are taken daily, at the same moment, the hours selected being 7 A.M., 3 P.M., and 11 P.M., Washington time. By this plan the changes from hour to hour and day to day, as well as the effects which are produced by these alterations, are noted, and after being forwarded to the central office are reproduced in a permanent form upon the daily weather map which is transmitted as far as practicable over the country.

Hence these daily maps may justly be entitled "the geography of our atmosphere." Without examining them we can no more secure an accurate conception of the general state of the weather than we could gain a correct idea of the real arrangement of seas, continents, and islands, as represented upon geographical maps, by walking a few miles along the coast or climbing over a range of mountains.

The benefits from a sanitary point of view to physicians, and indeed to

Signal Office are further instructed: "It will be frequently noticed at the time of sunset that the western sky, while exhibiting generally the characteristics of a fair-weather sunset, is tinged more or less and in different places with the colors yellow or green. It is important that these colors should be carefully noted. In some instances the sunset will be found a decidedly yellow sunset, that being the predominant color of the western sky. The color green is rarely the predominant color, but portions of the western sky will sometimes markedly exhibit it." Records are to be kept at each office showing the non-verification or verification of these sunset predictions on the succeeding day.

The instruments supplied to each first-class station of the Signal Service are: two mercurial barometers, two exposed thermometers, two wet-bulb thermometers, two maximum thermometers, two minimum thermometers, two anemometers and one self-registering attachment, one large and one small wind-vane, a rain-gauge and a clock.

The instructions for suspending and reading the barometer are similar to those given in the body of this work, but the following suggestions are well worthy of reproduction here: "In moving a barometer even across a room it should be screwed up and carried with the cistern uppermost. For travelling it is provided with a wooden case. On steamboats or railroads it should be hung up in a stateroom or car, and the lower end firmly strapped to the side of the room or car, to prevent jarring. In wheeled vehicles (other than railway cars) (?) it should be carried by hand, supported by a strap over the shoulder, or held upright between the legs; but it must not be allowed to rest on the floor of the carriage, as a sudden jolt might break the tube. If carried on horseback it should be strapped over the shoulders of the rider, where it is not likely to be injured, unless the animal (quadruped) is subject to a sudden change of gait. When required for use it must be taken from its case, gently inverted, hung up, and unscrewed. While it has the cistern uppermost the tube is full—is one solid mass of metal and glass—and not easily injured; but when hung up (in position) a sudden jolt might send a bubble of air into the vacuum at the upper end of the tube, and the instrument become useless until repaired. Observers must never *swing* the barometer or endeavor to force the mercury against the top of the tube without first screwing up the large adjusting screw at the base of the cistern. If the cistern should become dirty it can be cleaned safely and without changing the zero of the instrument," for which directions are given. (See "Instructions to Observers of the Signal Service," 1881, p. 18.)

In regard to the exposed thermometer, it is ordered that it shall be hung in the regular instrument shelter, in such a way that it shall always be in the shade, and at least one foot from the wall of any building. "The readings must be made at all times, but especially in winter, through the panes of glass without raising the sash, when the shelter is built out from a window. When the shelter is built upon the roof great care must be exercised in making the readings, in order to prevent the instrument from being affected by the heat of the body or of the lantern at night. The observation must be made as rapidly as is consistent with accuracy." It is required that the correctness of the zero-mark on the scale of every thermometer be tested by immersion in melting ice for half an hour, four times annually.

Many points of detail in the manipulation of the maxima and minima thermometers given in the "Signal Service Instructions" are of interest to private observers, but want of space forbids their quotation.

who will measure the height above the ground and report it to the Signal Office. The measuring rod is graduated in inches and tenths of inches, and the proportion between the cylinder and funnel is as one to ten, so that ten inches upon the rod correspond with one inch of actual rainfall, one inch to one-tenth of rain, etc." Snow is directed to be melted and reported as rain, the fact of its being melted snow being carefully noted. When from any cause the snow cannot be melted its depth will be measured, and ten inches of snow reported as one inch of rainfall, the fact of its being so approximated being also noted.

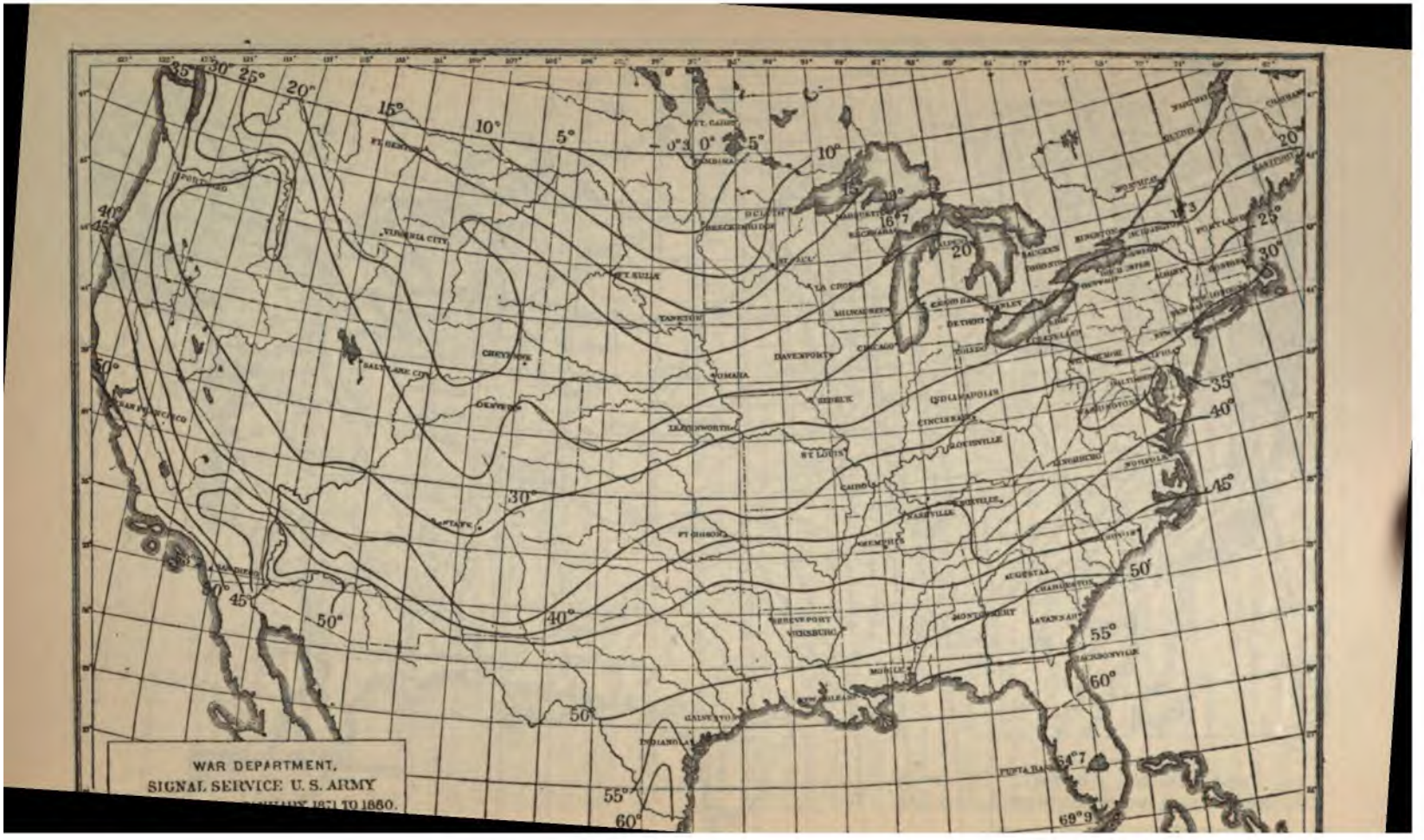
In regard to the appearance of the sky, observers are instructed to report the weather as *clear* when the sky is three-tenths, or less than three-tenths, covered with clouds; *fair* when the sky is from four-tenths to seven-tenths (inclusive) covered; and *cloudy* when the sky is more than seven-tenths covered.

The ingenious system of forwarding detailed reports at a minimum expense to the Government by using cipher words (such as "hub," which means "a thunder-storm with light rain, wind blowing from the north," or "rage," which indicates "rainfall since last report has been nineteen one-hundredths of an inch") is no doubt more or less familiar to our readers.

Besides the causes ordinarily enumerated as producing the atmospheric vicissitudes upon our globe and referred to in the body of this work, such as the motion of the earth upon its axis and the obliquity of that axis to the plane of the ecliptic, we have another fact, the importance of which has only been recognized within the last few years, and that is the movement of areas of low barometer across the surface of the earth, the consequences of depressions or furrows in the surface of our atmosphere. These areas of low barometer have a general tendency to move over us from west to east. As a rule, therefore, when the area of low barometer is west of us we may expect a storm, and although this storm may pass by us, either nearer to or further from the North Pole than the spot we occupy, without causing our neighborhood any great disturbance, it is almost certain to cross our meridian at some point. After that transition has been effected the winds, following as they do the course of such a depression in our atmosphere, will blow over us in an easterly direction, varying to the northeast or to the southeast, perhaps, according as the storm-centre happens to be travelling above or below our parallel of latitude. The clouds will of course be blown along from the west by the winds which are hurrying across toward the area of low barometer, which has now progressed to the eastward of our station, and after a few hours or a day, depending upon the magnitude of the cloud accumulation, we will see the blue sky again, and know that this particular storm is over.

Although we usually find that it takes three or four days for another area of low barometer to reach our individual locality, we must remember that there is no absolute certainty about the distance between these centres of storms. Another low-barometer area may advance upon us in one or two days, or, on the other hand, the one next following may progress so slowly, or may be diverted from its track in such a way that it may not come to us for five or six days, and when it does arrive, attack us from another and totally different direction.

The path of an area of low barometer across the country has been rather fancifully yet aptly compared to the track of an immense water-cart, the centre of which is of course the line of most violent storm. The average rate of such a storm-centre is, according to Prof. Loomis, 26 miles


WAR DEPARTMENT,
SIGNAL SERVICE U. S. ARMY

VENTILATION AND WARMING.

By D. F. LINCOLN, M.D.

The subjects of ventilation and heating have to be studied, in America, from a point of view somewhat differing from that taken in England. As regards the requirements of cubic space and supply of fresh air, there is and can be no difference. But in certain respects, for example as regards the standard of temperature to be maintained, we find ourselves unable to adopt English rules, and the English would be equally unwilling to accept ours. The severity of our seasons, too, has forced us to make use of steam and stoves to a much greater extent than is usual in England, while the old-fashioned method of warming by the fireplace has fallen too much into disuse among us.

Hot-air Furnaces.

When the inmates of a private house seek comfort, their first thought of improvement is in the direction of increased warmth. The halls are to be made as warm as the rooms; the sleeping-rooms are to made comfortable for occupancy by day; and to effect this purpose, a furnace in the cellar is the most feasible means, if the house be of moderate size. A house of more than three large rooms on the ground floor, however, with one or two stories of rooms above, cannot be properly heated by one furnace (Philbrick). However powerful the apparatus, it is unsafe to try to conduct heated air more than six feet in a horizontal direction from the furnace. Neither should we attempt to conduct a hot-air flue against the direction of the prevailing wind, in exposed situations. If a windward room cannot be warmed, because the furnace air refuses to enter it, the remedy is to open a chimney flue in the room; it may be necessary to light a fire to increase the draught of the chimney. Air cannot be forced into a tightly closed room: a failure to warm such a room is remedied by opening a discharge for the air from it. Flues supplying different rooms sometimes "draw against each other," as chimneys will; this is likely to occur when the supply from below is not sufficient for all, either because the air-box, or inlet of fresh air to the furnace, is too small, or because after it has been closed in a high wind some one has neglected to open it. A most eccentric effect is sometimes produced when a current of hot air passes *out* of the orifice for supplying fresh air to the furnace, while the air is sucked downward from the rooms.

The best way to heat a house at moderate expense seems to be by a combination of hot-air furnace in the cellar, and open fireplaces in the rooms. The false fireplaces, with dummy mantels, which take the place of the true in cheap houses, violate not only the principles of taste, but the laws of ventilation. An open fireplace in a closed room is very useful, not

The advantage possessed by both hot-water and steam over hot-air furnaces consists in the power of transferring heat to any desired point. Both ought to be combined with arrangements for ventilation, as, for example, in the sketch of a window-radiator (Fig. 104).

The extent to which heating by steam is carried is illustrated by the State Lunatic Asylum at Indianapolis, which has a total volume of rooms = 2,574,084 cubic feet, warmed by 34,100 square feet of radiating surface (two-thirds indirect). Steam is successfully supplied by companies in New York to private houses through street mains, like gas. Technical improvements in the art of steam-fitting have been made in great numbers by American mechanics.

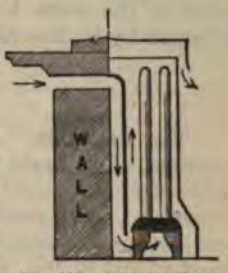
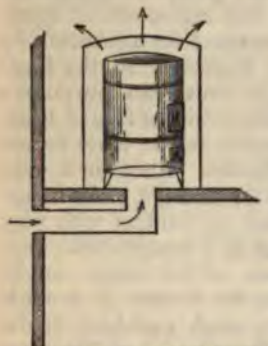


FIG. 104.—Inlet for Fresh Air under Window. (Gouge.)

Steam heat, like furnace heat, is apt to be excessive in mild weather. Shutting off steam is not always adapted to the circumstances. If a large building is to be warmed by the aid of propulsion, the method may be suggested which is believed to have been first proposed by Major-General M. C. Meigs, U. S. A., for the United States Capitol at Washington, in 1856. He placed a large auxiliary warming coil at the entrance of the main supply-flue that leads from the fire into the building. By shutting off parts of this coil and by the use of by-passages and regulating shutters or dampers, the air entering the main supply-flue to the building can at all times be warmed to a uniform temperature of, say, 50° F. Air at this temperature can be safely conducted to special coil-boxes in any part of a building, where it receives any desired addition of heat, and enters the rooms at from 50° to 120° F., as may be needed. This arrangement is economical of steam-pipe.

VENTILATING STOVES AND GRATES.

The principle of supplying fresh warmed air by fireplaces and stoves in the room has been applied in several ways in the United States. The "Galton" stove seems not to be manufactured here; its place is taken by the Fireplace Heater, and the Fire on the Hearth, the Dimmick Heater, and the Jackson Fireplace. A series of experiments by J. P. Putnam [1] gave the following results as regards the percentage of heat rendered available for warming a room. By an ordinary fireplace, six per cent. of total heat generated; Fireplace Heater, thirteen per cent. with wood, twenty per cent. with coal; Dimmick Heater, eighteen per cent. with wood, twenty-five per cent. with coal; Jackson Fireplace, wood, twenty-seven per cent. An improved arrangement of flues would add five per cent. to these figures. The Fire on the Hearth is mentioned by Youmans as supplying, with a small-sized stove, over ten thousand cubic feet of air at 160° F. in an hour, the outside temperature being 46°; it is a movable cast-iron stove, while the others are set in the chimney.


FIG. 105.—Stove with Fresh-air Supply.

It is to be hoped that the "ventilating fireplaces" will be largely introduced into the better class of houses.

[1] The Open Fireplace in all Ages, by J. P. Putnam. J. R. Osgood & Co., 1881.

may be said on both sides. Some persons seem to require a moist air. A fine jet of water thrown into heated air gives a pleasant quality; it cools it, also. On the other hand, much of the complaint of "dried-up" air can be remedied by ventilation, as already stated; and in hospitals, where a liberal supply is afforded, a very low proportion of moisture is compatible with a very pleasant effect upon the senses, and good hygienic results. The requirement of seventy per cent. of saturation is inapplicable to this climate.

In illustration of the difference between the American and the English standards of temperature and humidity may be cited the observations (1) of Surgeon D. L. Huntington, at the Barnes Hospital, Washington, and (2) those of Dr. Cowles, at the Boston City Hospital—places presenting very considerable differences in climate.

1. First week in December, 1877.—Average external temperature, 38½°; average temperature of wards, half way to ceiling, from 71° to 76° F.; average relative humidity of house, from 44 to 59; of outer air, 74.

2. Week ending December 10, 1878.—Average external temperature, 32° F.; humidity, 76; average temperature of air at head of beds in new ward, 68¾° F.; average relative humidity of ward, 29¼.

These data represent the degree of dryness which is not simply tolerated in our hospitals, but is habitual, and is consistent with a "peculiar feeling of freshness and purity perceived by those who enter the room." The uncomfortable sensations felt in some warm, dry rooms are ascribed by the late Robert Briggs to absence of moisture; but Billings and Cowles agree that they are caused by an insufficient supply of fresh air. The dryness is unavoidable unless water is evaporated in large amounts; and is much more marked in really cold weather, for instance, when the thermometer ranges from −20° to +20° F.

With these statements compare some in the present work. For example, the agreement for ventilating the Lariboisière Hospital stated the temperature required as 15° C., or 59° F.; and the memorandum issued by the Medical Department of the Privy Council in 1872, for the government of hospitals in towns, suggests "warming in winter to 60° F." (p. 358). As a provisional standard of humidity, De Chaumont's 73 per cent. is recommended (p. 153).

The advanced thought of this country upon the subject of ventilation will coincide, doubtless, in the statement that "the amount of supply for audience halls occupied for sessions not exceeding two or three hours' duration should in no case be less than 30 cubic feet of air per minute through the regular flues of supply, and in legislative buildings the apparatus should be such that at least 45 cubic feet of air per person per minute can be furnished, with a possibility of increasing it to 60 feet per minute when desired" (Billings).

Special Buildings, etc.

One of the most satisfactory small hospitals, in point of heating and ventilation, is the Barnes Hospital at the Old Soldiers' Home, near Washington. This contains four wards, in two stories; each ward has twelve beds, and an allowance of 1,500 cubic feet per bed. The wards are heated by coils of hot water, placed in air-chambers in the basement at the walls. The flow of water to each coil can be regulated by a cock; but it requires an hour for a coil to cool down, and an arrangement for more speedy change is to be desired. (See Figs. 105 and 106.) The fresh-air flues are of

above the ceiling, communicating with the ward by five openings. The former will be used for winter ventilation, the latter in summer. The ducts are of galvanized iron, or lined with that material to prevent leakage. Each ward will have a small propelling fan, designed to force air through the heaters and flush the ward two or three times a day. The heaters are placed in the basement of each ward, along the outer walls; they consist of steam-coils. The diagram (Fig. 107) shows that the supply of fresh air is taken from out-doors; but the air of the basement (which is used for no other purpose) can in cold weather be drawn upon. The "basement" is not a "cellar," being wholly above ground.

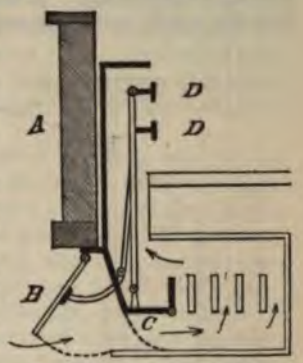


FIG. 107.—Massachusetts General Hospital. *A*, House-wall. *B*, Valve-opening through wall. *C*, Valve for regulating heat, in position to give the greatest heat. *D*, Handles for working *B* and *C*, placed close to register in ward.

The Boston City Hospital (375 beds), finished in 1864, on the pavilion plan, was at first supplied with air forced through underground brick ducts, exposed to pollution. The system for the original pavilions has since been entirely changed; propulsion is abandoned, and local steam-coils are placed in air-chambers under the points to be supplied. The beneficial effect upon the health of surgical cases was shown by the fact that the rate of deaths from compound fractures fell from forty-one to twenty per cent.; after amputations, from forty-four to thirteen per cent.

Certain observations made in the new one-story wards have already been mentioned. These wards are $94 \times 26\frac{1}{2}$ feet in the clear, and with curved roofs averaging 18 feet 5 inches in height. Each has twenty-eight beds, giving $88\frac{1}{2}$ square feet of floor-space, and 1,629 cubic feet of air-space to each bed. Air is introduced as in the Johns Hopkins wards, and is removed through ridgepole ventilators without traction. A general uniform upward movement is observed, with little tendency to areas of stagnation. Analysis gave the following results: mean carbonic acid, 0.0505 per cent.; that of outside air, 0.0325; air-supply per head per hour, 3,333 cubic feet; respiratory impurity, 0.018 per cent.

The accompanying diagram (Fig. 108) gives the curve of the central axis of the hot air currents entering the room from opposite sides. It passes through points of greatest velocity, ascertained by measurements by anemometer, taken at intervals of a foot in perpendiculars erected on the points A, B, C, D, D, C, B, A, the latter being three feet apart. The drawing is to scale, and shows that the horizontal impulse is nearly expended at D, about seven feet from the floor and nine feet in from the walls. Above the height of twelve feet the general upward movement becomes sluggish, to be much quickened near the point of exit E. It is thought that the air might leave the room more quickly, with less risk of readmixture, if the ceiling were lowered to the height of at most fourteen feet.

The New York Hospital has four stories There is one window to each bed. The foul air flues are contained in the external piers, which are lined with hollow brick to prevent the escape of heat. The openings for discharging air from the wards are, partly near the ceiling, partly near the floor, and one under the middle of each bed. Hot air is conveyed by cast-iron tubes running through the middle of these flues, fitted so as to be air-tight; but this collocation of foul and fresh air tubes seems questionable.

tilated upward. The supply is 1,500 cubic feet per hour and head; the theatre seats 650 persons.

The New York State Reformatory at Elmira contains 500 cells. A block of cells resembles a huge one-story shed, through the middle of which runs a pile of boxes, two deep and three high. The boxes represent cells. The free space near the outside walls is supplied with warm air from below; this freely enters at the grated doors of cells; the foul air passes out by two orifices in the rear wall of each cell, one of which is so arranged as to ventilate the niche for the night-pail. The foul air ducts are 4×4 inches, and terminate in heated chambers and aspirating chimneys in the roof. The intake of fresh air is in a tower, and a fan is used to force the current.

One of the best ventilated churches in the United States is said to be the Presbyterian Church in Fifth Avenue, New York (Dr. Hall's), which has a capacity of seating 2,000. The intake is by a tower 100 feet high, and the supply is from 10,000 to 15,000 cubic feet per minute, depending on the speed of the fan. At the lower rate of speed, and with a congregation of 1,400, the result, after a service of an hour and a half, was a proportion of $12\frac{1}{2}$ parts carbonic acid per 10,000. The fan, however, is continued in operation during the interval of morning and afternoon service, thus thoroughly flushing out the room. The entire basement story forms an air-chamber, from which the warmed air passes through openings in the risers of the stationary foot-benches of each pew, the supply to each pew being under the control of its occupants. The air-supply is warmed, first, by 4,410 feet of steam-pipe in the duct, just after passing the fan; second, by 9,000 feet of pipe fixed to the ceiling of the basement. The latter pipe aids greatly in warming the floor.

A plan of combined heating and ventilation has become popular in the Lake States and Canada, under the name of the Ruttan system. The proprietors profess to produce remarkable heating effects by means of large tubular cast-iron furnaces, which are said to weigh, in general, four times as much as "ordinary stoves" (their largest weighing 5 tons). Owing to their size, they are able to warm large amounts of air to a point not above 90° F. The foul air is extracted by openings in the base-boards, close to the floor, and thence passes under the floor to an exhaust-shaft heated by an iron smoke-flue. It is said that the air is changed once in half an hour or less.

The principle of induction of air-currents is applied in Gouge's ventilator. This consists of a small metal tube, heated by a gas-jet, with an open end near the floor; at a sudden enlargement, near the ceiling, a second opening is made, into which air is drawn by the inductive force of a current already established. If the tube passes through another story, other openings and enlargements are made. The principle of induction is the same that is used in the water-blasts, for ventilating mines.

Where funds are scanty, a very cheap and fit plan is to run plain straight tin pipes from some point near the floor to a point above the roof, capping them to prevent rain and wind from entering. There must be no bends, and no exposure to cold until the roof is passed. While the house is warmed, the current in such pipes is constant.

"Aspiration from above" is used in many schools and institutions. Pipes are run upward from the rooms to one large tin-lined box in the garret, which is heated by steam, and discharges through the roof. The plan is adapted to old buildings without flues, provided the pipes run straight. For dormitories, it may serve a very excellent purpose.

REMOVAL OF HOUSE-WASTE.

By EDWARD S. PHILBRICK, M.A. S.C.E., Boston, Mass.

The Need of Prompt Removal.

The opinion of all intelligent persons is unanimous upon this question. Nevertheless the practice of most communities is very far behind the theory. It needs no argument to convince us that it is not proper or conducive to health to allow fecal matter or organic waste in any form to accumulate, either in the interior of our dwellings, or in their immediate vicinity. Nature has given us a sense which is disgusted by such practices, and it requires no high degree of refinement to condemn them from the tribunal of good taste alone, without recourse to hygienic laws or local statistics.

It seems strange that, with such unanimity of opinion, no better devices should be used by the majority of our people than the old-fashioned privy with its vault, or the more modern water-closet with its cesspool. The former is often located within the house-walls, or under a roof connected with the house, while the latter is rarely far from the dwelling, even when the house-lot is large enough to allow it to be so.

This firmly rooted custom probably originated in the popular belief in certain supposed powers of the soil for purification and disinfection. But this belief is founded on a fallacy which we think it quite time to expose.

Soil is capable of such action only to a very limited extent, depending mostly for its efficiency upon the oxygen in the air which it holds in its pores, or upon the plant roots which may find their way into it.

When once the soil has become saturated with filth around a vault or cesspool, its purifying power ceases and can never be resumed, unless air or the roots of plants can penetrate the mass. It is evident that these agents have a very limited access to the soil around a large majority of the cesspools and vaults now in use. In cities or towns, very little if any such absorption by roots, or thorough decomposition by air in the pores of the soil, can be possible

The inevitable result, then, is an accumulation of a dangerous, putrescent mass, which would not be tolerated if it happened to be within the reach of our senses. It is certainly not the part of intelligence or wisdom to ignore these facts simply because they do not constantly offend the eye or the olfactory nerves.

The evil influences arising from such accumulations are manifold. Wherever the water supply is drawn from wells or springs near the house, the drinking-water is liable to become infected with the germs of contagion. This may happen though the well is on higher ground than the cesspool or vault. For the supply of water is drawn from the *bottom* of the well, which is generally twenty feet or more in depth, and often below

and that there was abundant opportunity for the dejections of a man ill with typhoid fever to pass into the water which his family were in the habit of drinking. No other cases of typhoid fever were known to have occurred in the vicinity during the summer."

Other cases of a similar nature and with similar results are cited in the same report.

It may be argued, however, that wells are fast being abandoned in our towns and villages, and that wherever circumstances admit, water is introduced by street mains for public use.

No one will question the advantages of a public water-supply, when a proper and reliable source is found; but it must not be supposed that such an improvement renders the privy vault and cesspool harmless or even tolerable. The people may get pure water to drink, but other and new sources of trouble arise as follows:

As soon as water flows freely from faucets, and the labor of pumping is avoided, the consumption of water for domestic purposes is found to increase at least fivefold. Indeed, the leakage from imperfect and cheap fixtures is often enough to raise the amount to ten or even twenty times the quantity formerly raised by hand pumping.

The quantity of filth discharged from the house may not be increased, but the volume of sewage which is thus sent into the cesspool is soon visibly in excess of its powers of absorption. Sometimes the cesspool overflows upon the surface, making a nasty place in the grass overgrown with rank herbage.

Sometimes it soaks through the ground along the outside of the house-drain which brings it and makes an entrance through the joints of the cellar-wall. The writer recently saw a case where sewage had thus soaked in under a pile of coal, out of which the foul stuff slowly worked its way about the cellar floor.

It often rises in the cesspool above the mouth of the inlet-pipe, stopping the usual circulation of air through the drain. This is almost always followed by the forcing of foul gas through the traps in the basement story. The undue pressure finds new leaks in the drain, and works untold mischief where least seen and least thought of.

Even when the workmanship is perfect, a result but rarely found, the result is far from desirable. The owner constructs new cesspools one below the other, till every available place is exhausted, and the pollution reaches his neighbor's lot without affording relief. The absorbent powers of the soil soon become overtaxed and the accumulation continues, crowding into every crack till all the soil in the vicinity of the house is a mass of corruption. The more water the family use, the worse is the nuisance. The apparatus for cleaning vaults and cesspools is repeatedly called upon, and the neighbors all become disgusted with the operation, while the cost of these frequent emptyings becomes onerous. The soil about the house thus becomes pestiferous. Emanations are constantly going on during the summer which are certainly depressing to the vigor, if not actually poisonous.

Now what is the remedy for this? A candid investigation of the case can lead to but one reply, viz.: That the development of a system of public sewerage must progress *pari passu* with that of a public water-supply.

The administration of any town or city that ignores this maxim is surely planting the seeds of future pestilence, while seeming to promote the welfare of its people. The demand for a supply of water is naturally more easily appreciated by the masses than the need of sewers. But it is quite

to make trouble as the alvine discharges. In view of these considerations it is not surprising that the system of removal of filth by *water carriage* should be already largely accepted by our people. Its popularity is indeed so great, that scarce any other method is known or considered in the hundreds of new towns which are constantly springing up all over the West. In fact, the use of the water-closet is not confined at all to towns or houses provided with a public water-supply. It has become a matter of course in the country house as well as in the village or city.

It is, therefore, to be taken for granted now that every good house must be provided with this convenience. It has become rather a necessity than a luxury among all who can afford its moderate cost. Accordingly, the cesspool, among all suburban districts as well as in many villages and towns, has taken the place of the old privy vault.

So far as the closet goes, if properly devised and ventilated, properly located and constructed, it is a long step in advance of the privy. But the gain is not a great one if the ordinary leeching cesspool is the receptacle of the discharges.

The only proper disposal of the flow from water-closets, among all communities that can afford it, is a well-devised system of sewerage delivering the flow either on the land or into the sea, but not into any small rivers or watercourses whatever.

This, of course, is applicable to large towns and cities, not to a scattered population, the needs of which it is proposed to consider later.

The development of a proper system of sewers is entirely a local question, and should be studied and perfected by experts in every locality where it arises. Yet some general rules have been established by the experience of the first twenty years which it would be best to conform to in all cases.

Ultimate Disposal of the Sewage.

First, as to the *ultimate disposal of the sewage*. This subject has been so thoroughly probed and discussed that we can avail ourselves of the investigations of some of the most intelligent men of our day. "In Berlin a scientific commission was appointed in 1862, and made exhaustive experiments, continued through many years. They proved by scientific analysis and by induction, what had long before been learned in England by practical experience.[1]

"I. That with cesspools and privies, the soil and well-water become dangerously polluted.

"II. That sewers need not pollute the soil.

"III. That streams become so foul when used as receptacles for sewage, that measures must be taken for their purification.

"IV. That the only practicable means of purifying sewage is by irrigation."

"They have, therefore, adopted a sewerage system which is to be completed in 1883, and which provides for the purification of the sewage by irrigation."

In 1876 a committee was appointed by the Local Government Board of England to inquire into the several methods of treating sewage. This Committee arrived at the following conclusions, which are quoted from their report:

[1] Seventh Annual Report of State Board of Health for Massachusetts, 1876, p. 310.

rainfall, which in our climate often brings into the sewers connected therewith a volume of water some twenty to thirty times as great as that of the sewage alone. It is sometimes found, as at the city of Memphis, Tennessee, where the separate system is used, that a six-inch pipe is sufficient to collect the sewage for a continuous length of over half a mile of street, lined with houses; while if the rain-water were to be provided for, a conduit of many times that capacity, with a corresponding cost, would be required.

The second advantage referred to, that of freedom from deposit, arises from the frequency of the maximum flow in small pipes, which causes such sewers to be *self-cleansing* to a greater degree than in larger ones. The small sewers are likely to be half filled by the daily flow, during at least a part of the day, while the large ones, proportioned for carrying rain-water, may be so filled only at rare intervals, during heavy rains, and for a great part of the time they carry only a driblet, say five or six per cent. of their whole capacity. The small pipe can be flushed daily by a moderate expenditure of water, and should be so flushed, while the large sewer would require a larger quantity of water to properly flush it than most towns could conveniently supply. It therefore would seldom get flushed except by heavy rains, which occur at long intervals, between which serious deposits may sometimes occur.

Another and a very important reason for keeping the sewage separate from rain-water exists in all those localities where the sewage must be artificially treated in any way, either by chemicals or otherwise; also where it must be pumped to bring it to the desired place for ultimate disposal, or where it is used for irrigation of crops. It is evident that it would be a great drawback upon any system for handling the sewage, if the plant for this purpose must be adapted to a maximum flow that occurred only at long intervals and for short periods, after heavy rains, leaving a large portion of this plant idle for three-fourths or nine-tenths of the time.

If sewage is disposed of by irrigation, which, as we have seen above, is recommended as the most satisfactory method of purifying it, the only way to recover any part of the cost of the process is to apply it to growing crops. If a considerable part of the rain-water is mixed with the sewage, this great difficulty arises, viz.: The whole flow must be disposed of daily, and no crops can thrive if subjected to flooding in periods of rain, while but scantily watered in times of drouth. In short, the farmer could not raise a crop with profit who was obliged to take ten times as much water as his crops need after a rain, even if supplied tolerably well in the drouth.

The objections to the separate system are as follows. It will be seen that they apply with considerable force in large towns, or those of dense population, and as many towns now small and scattered may hope to become large and dense, as experience has shown they often do in our country, it behooves such towns to be cautious about committing themselves to a system which may bring much trouble eventually, and prove in the end to be *more* costly rather than *less*.

It is found that wherever the streets are paved and the traffic is large, the flow of water from their surfaces after a rain, and more especially after the melting of winter snows, is as foul as the flow in the house drains, and therefore as unfit to be conducted into running streams or ponds as any form of sewage. In fact, the street wash of Boston or New York, when the snow is melting in April, is so foul that no proper disposition can be made of it separately from the sewage, and therefore no plan for so separating it could be reasonable, expedient, or productive of good results.

have hitherto taken no efficient steps to check in most cases. The enormous expenditure for fixed plant in water-works which has taken place in cities like New York, Philadelphia, and Boston, with the actual quantities of water now distributed, would, if properly husbanded, supply liberally fully twice the present population in these cities. No large city of this class can ever dispose of their sewage upon the land with a hope to produce crops by irrigation, till some way shall be provided for checking this prodigal waste of water and thus rendering the sewage less dilute in its character. The sewage farm at Barking, on the Thames, has a small portion of the sewage of London to dispose of, and its profits have been reduced to a microscopic amount, if not a negative quantity, by this superabundance of water. Yet the quantity of water distributed per capita of population in London is far less than that enjoyed and wasted by the large American cities. The following table is made up from "Croes' Statistical Tables," giving figures for 1880, for eleven prominent American towns, while those for London are taken from official reports quoted at London for the same year, in *Engineering* (vol. xxx., p. 195).

Consumption of Water in 1880, *in various American Cities, compared with London.*

City.	Population.	Gallons daily.	Daily consumption per capita.
New York	1,206,299	95,000,000	78
Philadelphia, Pa	847,170	67,647,782	80
Brooklyn, N. Y	566,663	34,616,831	61
Chicago, Ill	503,185	66,163,942	131
Boston, Mass	362,839	38,214,700	105
St. Louis, Mo	350,518	27,500,000	78
Baltimore, Md	313,190	25,000,000	79
Cincinnati, O	255,139	19,524,847	76
San Francisco, Cal	233,959	13,824,000	59
Pittsburgh, Pa	156,389	16,021,624	102
Washington, D. C	159,871	26,525,991	166
London, England[1]	4,388,000	150,398,107	34

But it is the opinion of all sanitarians, that for all inland towns having no opportunity to discharge their sewage into the sea or some large river in a way which would create no nuisance, the purification of their sewage becomes imperative. For this purpose irrigation is the only rational method of treatment, and should be adopted, even if the crops produced are not a source of profit. If the notion of profit is abandoned as unattainable, the process may be much simplified by allotting more sewage to the

[1] The consumption in London is doubtless reported here in imperial gallons of 288 cubic inches, while the American cities reckon by wine gallons of 233 inches only. This would require an addition of 25 per cent. to the figures given for London to make the comparison fair; but on the other hand the consumption in London is reported for the month of July only, which is doubtless larger than the average for the year, perhaps by an equivalent ratio. Moreover, the report of the London official gives only the population actually served with water in their houses, which we suppose to be a smaller ratio of the whole population than is the fact in American cities.

area treated than the crops could be expected to profitably use, and removing the water by under-drains after it has filtered through the soil. Such a process cannot be kept up continuously with success. There must be intermission by means of two or more fields for alternate treatment, giving each field such period of rest as will enable the water with which it is gorged to soak down and admit the air to the pores of the soil. It is this very air in the pores that does the work of chemical purification by means of its oxygen, which process is more important and more efficient for the purification of the effluent water than the straining or mechanical filtration.

This process is perfectly applicable to villages and small towns, and requires less expenditure for its maintenance than is generally supposed. It is not entirely automatic, however, and needs frequent attention in diverting the flow from one plot to another, as often as the soil becomes saturated. Such attention, however, would not be an onerous tax upon a village of a thousand inhabitants or more.

Irrigation below the Surface.

For all small villages or collections of houses, as well as for single houses in the country where the land is not entirely flat, a distribution of the sewage can be made, about a foot below the surface, by porous tiles, which has been tried both in England and this country with success; and the process is nearly automatic when the apparatus is properly prepared, requiring attention only at long intervals. The requisites for this system are as follows:

First.—Land adapted to grass, nearly level or gently sloping, at the rate of one-fourth of an acre for a single family, or an acre for a combination of eight to ten families, if provided with a constant water-supply under pressure. If the water-supply is limited to what may be pumped by hand, one-half of the above area will be ample.

Second.—The highest part of the land devoted to the purpose should be at least five feet below the level of the top of the drain where it leaves the house.

Third.—The soil should be thoroughly under-drained, if not resting on a dry and porous subsoil by nature. Under-drains are often needed in clayey or retentive soils, and should be laid at least four or five feet below the surface, at intervals of about twelve feet, with a free outfall.

Fourth.—The land should be graded, unless tolerably smooth beforehand, so as to avoid sudden inequalities. A surface that is adapted to smooth mowing by hand is good enough for the purpose.

Fifth.—The soil must be entirely free from roots of trees and shrubs. These would choke the pipes in a few weeks.

The cost of the work will vary with the local conditions. It can be laid out by any intelligent mechanic, with an ordinary spirit level and straight-edge twenty feet long, though if on a large scale, requiring an acre of land or more to be treated, an engineer's level would be a convenience.

If house drainage is conducted directly into porous tiles laid under the surface, the fluid parts will escape at every joint, while the solid matter is apt to cling to the interior and gradually fill them, till they become practically useless, unless taken up and cleaned.

In order to avoid this result it is advisable to provide a tank or tight cesspool where all the sewage is arrested for a while, during which time

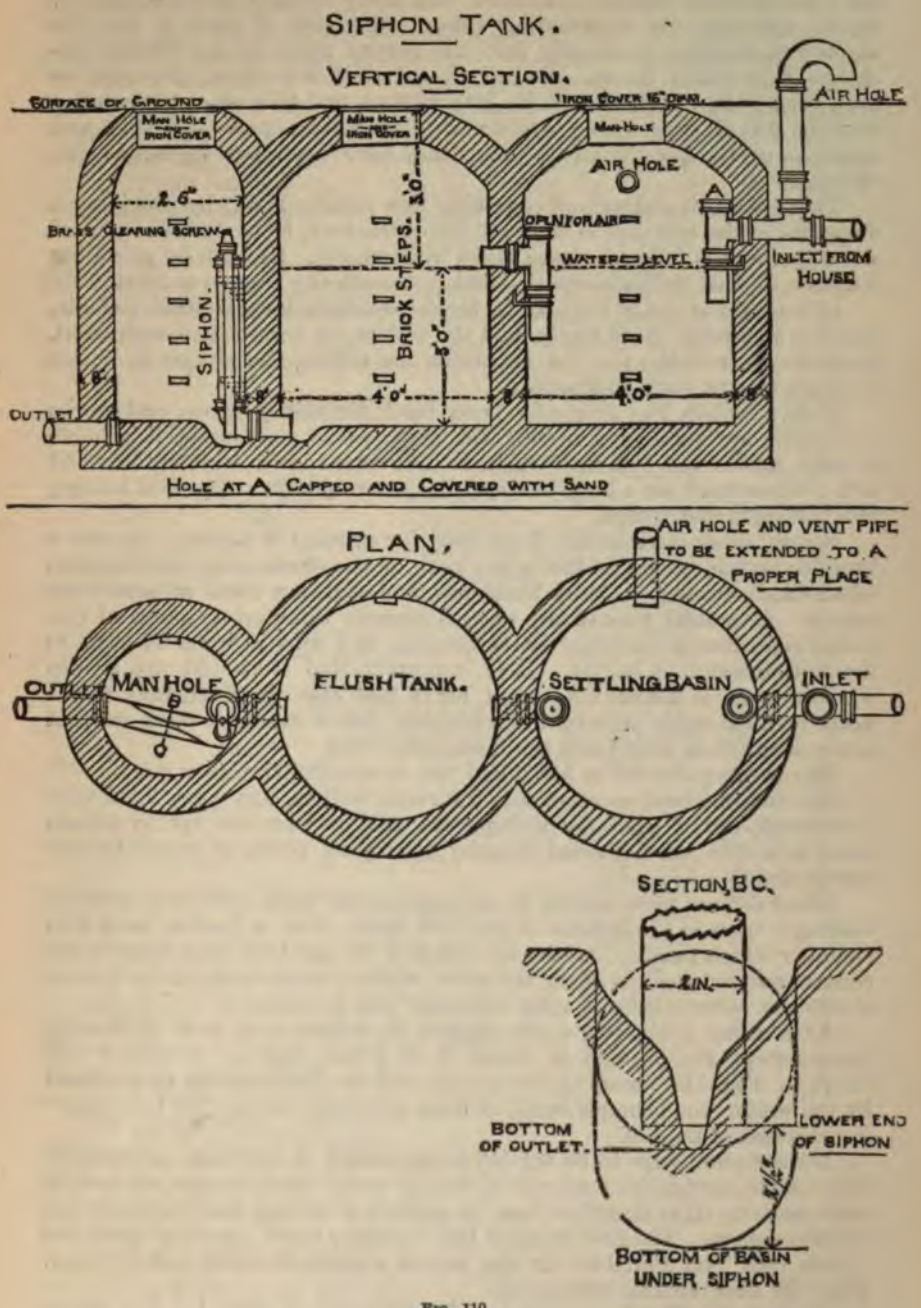

SIPHON TANK.
VERTICAL SECTION.
SURFACE OF GROUND
IRON COVER 16" DIAM.
AIR HOLE
MAN HOLE IRON COVER
MAN HOLE IRON COVER
MAN HOLE
AIR HOLE
A
2.6"
BRASS CLEARING SCREW
SIPHON.
BRICK STEPS.
3'0"
3'0"
OPEN FOR AIR
WATER LEVEL
INLET FROM HOUSE
4'0"
4'0"
OUTLET
HOLE AT A CAPPED AND COVERED WITH SAND
PLAN.
AIR HOLE AND VENT PIPE TO BE EXTENDED TO A PROPER PLACE
OUTLET
MAN HOLE
B
C
FLUSH TANK.
SETTLING BASIN
INLET
SECTION, B C.
2 IN.
BOTTOM OF OUTLET.
LOWER END OF SIPHON
BOTTOM OF BASIN UNDER SIPHON

FIG. 110.

the solid matters become macerated and finely divided by fermentation, before entering the distributing pipes. Moreover, if such a tank be allowed to overflow constantly into the porous pipes by a dribbling discharge, they would become choked after a while even then. In order to keep them free, the flow must be intermittent and take place with such a rush as to fill the whole system of distributing pipes at once, and brush away slight obstructions which may have been left by former discharges.

There are two methods of obtaining this result: First, by providing a stop-gate in the outlet-pipe where it leaves the tank, to be opened by hand when the tank is full and closed again when empty. Second, by providing a siphon or float to discharge the tank automatically whenever filled.

Of course the latter method is far more satisfactory, if made reliable, but it is somewhat more costly, and the siphon, as heretofore constructed, is *not* always reliable, *i.e.*, the apparatus for setting the siphon in action does not always work as expected.

Field's siphon has generally been used for this purpose, and works well with pure water; but if used with sewage on a small scale, it is liable to miss, unless the cup into which it discharges is occasionally brushed out. When used on a large scale, as for a combination of several houses, this difficulty disappears.

Several other devices have been used for starting a siphon. In one a tumbler tank is placed in the upper part of the flush tank, which upsets when filled, turning on brass trunnions, and righting itself at once when empty. A tumbler tank of two gallons capacity will start a siphon of two inches diameter, if the lower or discharging end dips in water as soon as the flow through it begins. It is important that it should not so dip when *no water* is flowing through it, for in that case the flush tank would never be filled again after once discharging; but it can be so arranged that a very slight flow would seal the discharging end.

The device patented by Mr. Field was to accomplish this result.

The tumbler tank accomplishes the result well enough when filled with pure water, but if used for sewage, the solid matters are apt to adhere more or less to its sides and thereby destroy its poise, on which its certainty of action depends.

Other devices have sought to accomplish the same end by a float actuating a valve in the bottom of the flush tank, or by a bucket in a side chamber which can be filled by the overflow of the tank, and thereby becomes heavy enough to open the valve, while a small leak in the bottom allows the valve to raise it again after the tank is empty.

All of these contrivances are subject to failure from wear of moving parts except Field's siphon, which it is hoped may be perfected still further. Fig. 110 shows the two tanks and the Field siphon as modified by the writer, the changes being at least a partial remedy for the imperfections complained of.

If the siphon were to be applied as the outlet of the same tank which receives the sewage for maceration, etc., it would often become choked by solid matter. It is therefore best to provide a second tank between this and the siphon. The first is called the "settling basin" and the latter the "flush tank" on Fig. 110, for the last is alternately filled and emptied, while the first remains always full.

Siphons are often constructed inside of the flush tank, but it is better to make them accessible at all times by placing them outside, as here shown.

A two-inch siphon is as large as can be surely set in action by the drainage of a single house.

The surest method of starting such a siphon would undoubtedly be to provide a copper float in the tank with an ordinary brass cock, such as is used on water-supply pipes for the automatic filling of house tanks; but the float must be adjusted so that the cock should be *opened* instead of closed, when the sewage rises to the overflow line of the siphon. Supply this cock with pure water under pressure from some outside source by a small pipe, and let the discharge be delivered by a tight connection through the arch of the siphon, in such a way that it would fall free of the sides of the tube into the cup or basin where the siphon is made to discharge. A very small stream of water, thus applied, would start the siphon with certainty, and with scarce a moment's delay, if its discharging end is so placed as to be sealed with water by a slight flow.

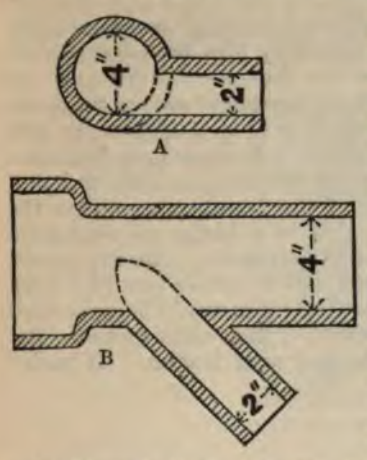


FIG. 111.—A, Section across Branch. B, Section lengthwise of Branch.

The outlet pipe for this apparatus should be four or five inch stoneware pipe for a two-inch siphon. If over one hundred feet in length, and on an inclination less than two in one hundred, the larger size may be preferable.

The distributing pipes should be cylindrical and two inches bore. The quantity needed will vary with the porosity of the soil and the size of the flush tank. The tank here shown contains $37\frac{7}{10}$ cubic feet when filled. The pipe should be of sufficient length to contain about one-half this amount, say 19 cubic feet. Since the sectional area of a two-inch pipe is 3.14 square inches, it will require about 46 linear feet of the pipe to contain one cubic foot. They should then be about 46 times 19, or 874 feet in length. If the soil is extremely porous, a smaller quantity would doubtless answer the purpose, since a larger proportion of the water would soak away while the siphon is discharging the tank.



FIG. 112.—Perspective View of Unglazed 2-inch Tiles with Troughs and Covers.

These distributing pipes should be laid with a perfectly uniform slope of not over six or eight inches in one hundred feet. Even less than this will often answer. If the slope exceeds this amount, the water may burst up at the lower end and make a nuisance. They should not be covered over eight or ten inches below the surface of the ground. In order to combine these two conditions, the ground must be somewhat smoothly graded, and the lines for the pipes must be laid out to conform to the contour of the surface, *i.e.*, the trenching must follow lines which have a surface slope limited as above stated. The trenches may be at intervals of

five or six feet, dividing the field in a gridiron fashion. The tiles must be laid one-fourth of an inch open at joints.

The branches where the two-inch pipes leave the main should be so made as to allow no fluid to be retained in the main, but lead from its bottom, as shown in Fig. 111.

The branches can be made rights and lefts to suit the places where used, and can be either of the Y or T form. Ordinary pipe-branches are intended for combining two streams into one, but these are for dividing one stream into two. They should, therefore, be formed as shown in the drawings, having no socket on the small hole, which is to abut against the first piece of two-inch tiles. These porous tiles have sometimes been laid upon boards bedded in the trench, to secure a more uniform gradient and prevent dislocation of joints; but the decay of the boards soon allows the pipe to become displaced by settlement, and it is better to place terra cotta troughs under the pipe, breaking joints therewith. Similar pieces, about four inches long, are placed over the joints as covers (see Fig. 112).

It is often objected to this system that the pipes would become filled with ice in Northern winters unless buried deeper than eight inches. But experience has shown that such is not the fact near Boston. If buried



FIG. 113.—Disposal of House Drainage by Surface Irrigation.

deeper, the roots of grass and the air do not get so good access to the sewage, which is therefore likely to accumulate—a result which we wish by all means to avoid. When laid near the surface no such accumulation occurs, and the frequent flow of warm water from the house prevents the ground from freezing under and around the pipes, if covered with sod.

In places where a sufficient slope exists, the sewage of single houses may be distributed on the surface with advantage. The above cut shows such a method, which has been in use for several summers at a house used only as a summer resort, and has been attended with complete success. There is an overflow pipe from the cesspool, which is perfectly tight, indicating when it is full. The gate in the outlet-pipe is then opened and the whole contents distributed on the kitchen garden in ten minutes. If an opportunity is selected when the wind is blowing from the house to the garden, no offensive odors are perceived, and the growing crops soon absorb the fluid, much to their advantage (see Fig. 113).

DISCONNECTING HOUSE DRAINS FROM SEWERS.

The complete separation of the air-space in our house drains from that in the public sewers is now insisted on by most European municipal authorities where regulations are enforced on such subjects. This separation is even more important in cases where a cesspool is used in place of a sewer, for the gases of the cesspool are much the more foul, and no

amount of ventilation will prevent their becoming so. The cesspool is but a retort where such gases are constantly evolved from the decomposition of the fluids and solids retained in them.

The devices for attaining this separation which are applied in England are not so well adapted to the climate of New England. Here the severity of the winters requires the separating trap to be placed several feet under the ground, and as it should be kept accessible, a man-hole or well is gen-

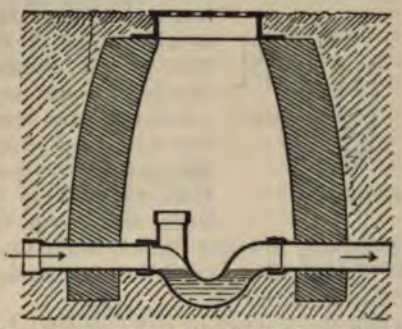


FIG. 114.—Main Trap and Air-hole for House Drain.

erally constructed over it in brick-work, with a perforated iron cover at the top, as shown in the annexed cut (Fig. 114). If this is used in a snowy climate, a bent pipe should be extended from the interior of the chamber to a point a few feet above the surface, where it may be protected by a wire-basket. Little or no offence is likely to arise from such an opening.

THE VENTILATION OF HOUSE DRAINS.

This subject has attracted much attention of late, and deserves careful consideration. The liability of the interior surfaces of house drains to become foul by the accumulation of solid matter, or from the formation of a slimy coating of organic matter on their interior walls, is well known, and the high temperature of the drains as compared with that existing in the sewers conduces to a more rapid decomposition of such matter than in the sewers themselves. A constant change or current of air through every part of the drain, is therefore essential to avoid the concentration of such gases. If such concentration occur, the risk of harm is multiplied, by the well-known law of diffusion of gases, by which they penetrate very small cracks, and through imperfection of workmanship or inefficiency of the water seal in the traps, might enter and mix with the air of the house. When houses are artificially heated this tendency is increased by the diminished density of the air within the house, causing a slight inward pressure through all such fissures.

Our best municipal codes now require the house drains to extend up through the roof over every separate "stack" or vertical line of soil pipe, of a size not less than four inches. This size is found necessary in order to avoid accumulation of frost by condensation at the top, and other reasons.

In order to provide a draft through these pipes, the fresh air should be freely admitted to the drain at its lower end, next to the trap by which it is separated from the outside drain and sewer.

Such an opening as referred to in connection with Fig. 114, can be made

to terminate anywhere above ground, and within a few feet of the surface, without risk of offence, for the draft is almost always inward. It is customary to terminate them by a pipe extending some three feet above ground against the yard fence, with some protection at the orifice, to prevent stones, etc., from being thrown in by children.

The need of a draft through every part of the house drain is not the only reason for their being open to the air at the top. It is impossible to retain the water seal in the best forms of traps—the most simple ones—unless the atmospheric pressure is freely admitted just below the water seal. The partial vacuum that follows a charge of water as it descends a vertical line of pipe is such that, without a free admission of air below every trap, the pressure on the house side of the trap would force the water through them and leave them unsealed. It therefore becomes necessary to apply branch vents to each separate tube (see Fig. 115). This is particularly needed in connection with waste pipes smaller than four inches in diameter.

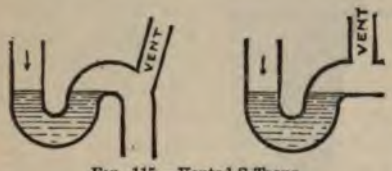


FIG. 115.—Vented S-Traps.

In order to ascertain the amount of risk incurred by lack of air in the outlets of traps, the writer was employed by the National Board of Health, in the summer of 1882, in connection with E. W. Bowditch, Esq., to make a series of experiments with apparatus constructed for the purpose. The following is an abstract of the report upon these experiments, published in August, 1882, in columns of the New York *Sanitary Engineer:*

"A typical stack of four-inch, and another of two-inch waste pipes were erected in a vertical position, extending fifty-seven and a half feet above the basement floor, with branches in the basement and on the floors above, and having the upper ends open to the air eight and one-fourth feet above the upper floor.

"The vertical pipes extended down to a point two feet above the basement floor, from which they turned to a slope, falling this two feet in a horizontal distance of thirty-two feet.

"The two-inch waste joined the four-inch pipe at a branch on this slope five and a half feet from the lower end of the vertical portion. A four-inch running trap was attached to the lower end of the slope, having a four-inch air-hole close above it, to represent the foot ventilation. At a point on the slope six feet below the lower end of the vertical reach, a branch was inserted with a four-inch trap in it, marked (n) on the plate, to represent an inlet for a basement water-closet, or for any other desired fixture at that level. The relative position of these branches and flows is shown on the accompanying plate (Fig. 116).

"Traps may lose their water seal by siphon action, *i.e.*, by lack of air-pressure, either when water is poured through them, or when poured through the main waste pipe into which they discharge from fixtures at a higher level. These two processes are, therefore, examined separately, as described below.

"Since it is now generally admitted that the upper ends of all soil or waste pipes should be wide-open to the air, all experiments were tried under this condition, except where otherwise noted for special purposes there explained.

"We will first consider the loss of the water seal in traps caused by water flowing through them from the fixtures attached thereto.

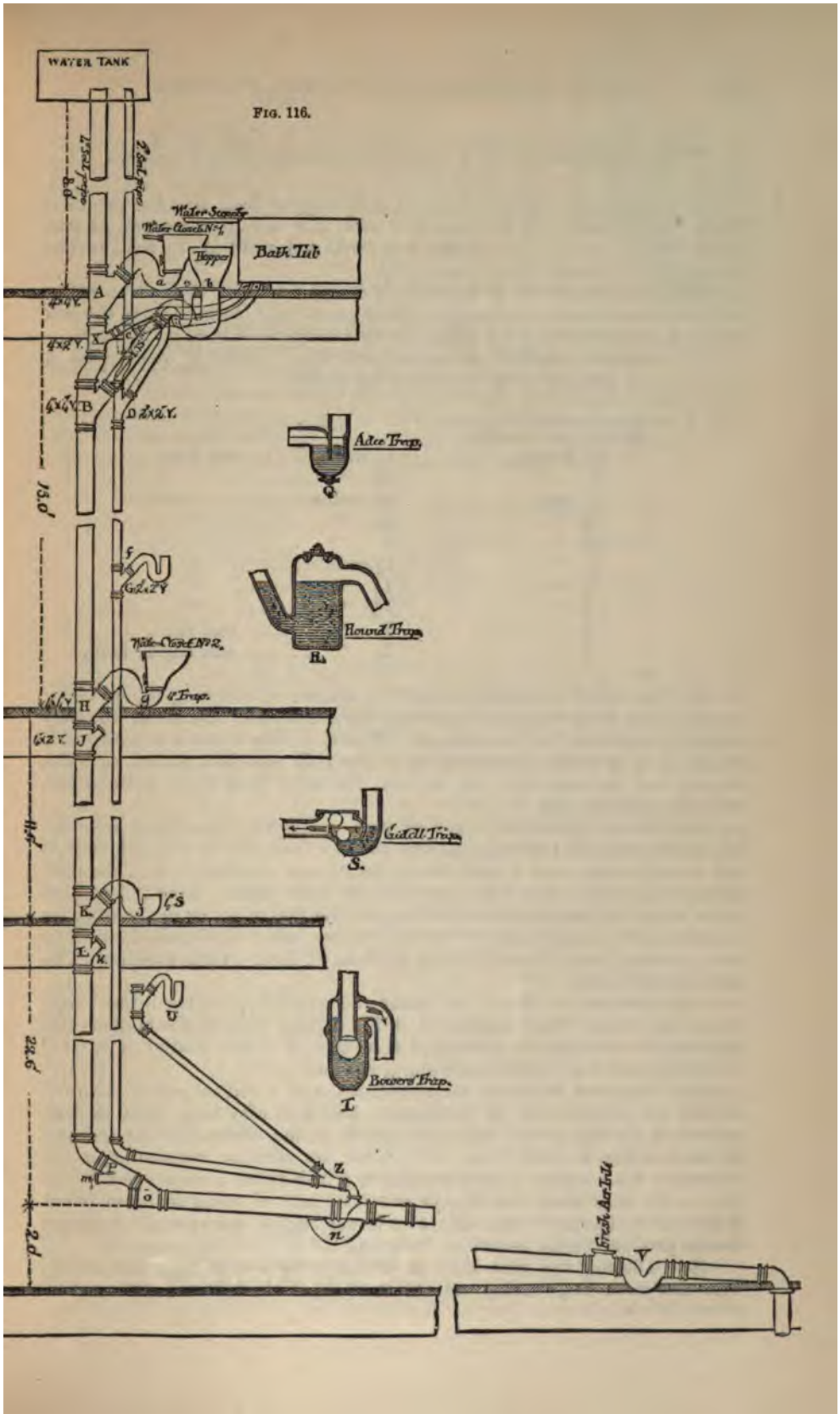

WATER TANK
Water Supply
Water Closet No 1
Hopper
Bath Tub
Adee Trap
Round Trap
Water Closet No 2
Gullett Trap
Bowers Trap
Fresh Air Inlet
13.0'
11.6'
23.6'
2.0'

FIG. 116.

"A. *Experiments with a Two-inch Waste-pipe, open at the Top.*

(1) "A conical hopper was placed at the upper floor, over the two-inch S-trap at (e), having $1\frac{5}{8}$ inch depth of seal, and having a branch of two inches calibre twenty-one inches long, with a descent of one foot, before joining the Y-branch on the main at D.

"This trap was found to lose its seal completely every time a two-gallon pail was emptied into the hopper, unless pains were taken to pour the last part of the water slowly, by which the seal might with care be restored.

(2) "Smaller quantities of water were then poured in quickly, as is often done in practice, with the following results:

Quantities poured in expressed in depths of water in the pail.	Loss of water in trap.
3 inches.	$1\frac{7}{8}$ inch.....seal lost.
2 "	$1\frac{3}{4}$ " "
$1\frac{3}{4}$ inch.	$2\frac{1}{8}$ inches "
$1\frac{1}{2}$ "	$2\frac{1}{8}$ " "
$1\frac{1}{4}$ "	2 " "
1 "	$1\frac{7}{8}$ inch "
$\frac{3}{4}$ "	$1\frac{5}{8}$ " "
$\frac{1}{2}$ "	$1\frac{7}{8}$ " "
$\frac{1}{4}$ "	1 " seal kept.
$\frac{1}{4}$ "	$1\frac{1}{2}$ " seal barely kept.

(3) "In order to test the effect of a strainer in retaining the water by checking the flow, two cross-bars were then inserted, just above the trap water, to represent a bar-strainer. Water, to the amount of one and a fourth inch in depth in the bottom of the pail, was then poured into the hopper, but the trap still lost its seal, the water in it being lowered one and three-fourths inch.

(4) "To test the effect of a vent pipe on this combination, a hole was cut at the crown of the trap, and one end of a lead pipe of one-inch calibre and twenty-eight and a half feet in length was coupled to it. The pipe lay in a coil on the floor with the other end wide open. Nine full pails of water were then emptied into the hopper, the loss of water in the trap, on measurement, being found to be as follows, after each pailful, viz.: $1\frac{1}{4}$ inch, $\frac{1}{2}$ inch, $\frac{3}{8}$ inch, $\frac{1}{2}$ inch, $\frac{5}{8}$ inch, $1\frac{5}{8}$ inch, $1\frac{3}{4}$ inch, $\frac{1}{8}$ inch, nothing. The seal was lost twice.

"The manner in which the water was poured influenced the result materially. Less water was lost if it hit on one side of the hopper and whirled about during its downward flow, than if it was poured in directly toward the centre, without such spiral motion.

(5) "The vent hole was then enlarged, and a coil of pipe of $1\frac{1}{4}$ inch calibre was coupled on to it, having a length of fifty feet. Ten pailfuls were then quickly poured into the hopper in succession, finding the loss of water in the trap after each as follows, the strainer remaining at the bottom of the hopper: 1 inch five times, $\frac{5}{8}$ inch twice, $\frac{1}{4}$ inch once, $\frac{1}{8}$ inch twice. So that there was always at least $\frac{5}{8}$ inch of water seal remaining. A shorter vent pipe of same size, or a larger one of same length, would of course produce better results by lessening the friction encountered.

(6) "Closing the vent hole, an ordinary wash-bowl was then placed over the same trap, having an outlet of $1\frac{1}{4}$ inch diameter, with a bar-

strainer. It was filled several times and discharged without losing any water that could be detected from the trap. Such traps often do lose their water, however, in practice, when discharging into smaller wastes, under circumstances otherwise similar, except as to the cleanness of the interior of the pipes.

"B. *Experiments with a Four-inch Waste or Soil-pipe, open at the Top.*

(1) "A conical hopper was placed on the third floor, on the four-inch S-trap, at (b), having a water-seal of $1\frac{7}{8}$ inch, with a branch twenty-two inches long between the trap and the Y-branch on the main.

"Five pailfuls in succession were poured into the hopper, with loss of water as stated below, viz.: $\frac{5}{8}$ inch, $3\frac{1}{4}$ inches, $2\frac{7}{8}$ inches, $\frac{3}{4}$ inch, $2\frac{5}{8}$ inches. The seal was thus lost three times out of the five. Smaller quantities of water were then poured in, with the following results, viz.:

Quantities of water in bottom of a two-gallon pail.	Loss of depth in trap water.
Half full.	2 inches.....seal lost.
$3\frac{1}{4}$ inches deep.	$1\frac{5}{8}$ inch.
$3\frac{7}{8}$ " "	2 inches.....seal lost.
5 " "	$3\frac{3}{8}$ " "
3 " "	$2\frac{1}{8}$ " "

(2) "A vent pipe, $1\frac{1}{2}$ inch diameter, and one foot long, was then inserted in the upper side of the pipe, six inches below the crown of the trap, and ten pails discharged in succession, with the result of losing the seal completely three times, and having but $\frac{1}{8}$ inch seal two other times, while the remaining five trials lowered the water respectively $\frac{3}{4}$ inch, $1\frac{1}{2}$ inch, $\frac{7}{8}$ inch, $1\frac{3}{8}$ inch, and $1\frac{1}{4}$ inch.

(3) "The size of the vent was then increased to two inches. Six successive pailfuls were emptied, lowering the trap water as follows, viz.: 1 inch, $1\frac{1}{4}$ inch, $\frac{7}{8}$ inch, $1\frac{3}{4}$ inch, $1\frac{5}{8}$ inch, $2\frac{1}{8}$ inches, the last losing the seal.

(4) "The vent pipe was then increased to three inches in diameter, still one foot long. Ten successive pailfuls were emptied, with losses of trap water as follows, viz.: $1\frac{3}{8}$ inch, $1\frac{1}{2}$ inch, $1\frac{1}{2}$ inch, 1 inch, $\frac{7}{8}$ inch, $\frac{7}{8}$ inch, $\frac{7}{8}$ inch, $1\frac{1}{2}$ inch, $1\frac{3}{8}$ inch, $1\frac{1}{4}$ inch. The seal being lost once.

(5) "This vent hole was then sealed up, restoring the original form of the pipe as far as possible, and another vent pipe of $1\frac{1}{2}$ inch diameter and one foot length was inserted on the highest part, or crown of the trap. Nine successive pails were emptied, with loss of water in the trap as follows, viz.: $1\frac{1}{2}$ inch, $2\frac{3}{8}$ inches, 2 inches, 1 inch, $2\frac{1}{4}$ inches, $\frac{3}{4}$ inch, $\frac{1}{2}$ inch, $1\frac{1}{4}$ inch, $1\frac{1}{4}$ inch. The seal was thus lost three times out of nine.

(6) "The vent pipe, still one foot long, was enlarged to two inches, with an elbow two inches long, at its upper end. Ten pailfuls in succession were emptied with the following losses in the trap, viz.: $1\frac{1}{16}$ inch, $1\frac{5}{8}$ inch, $1\frac{1}{4}$ inch, $2\frac{1}{4}$ inches, $1\frac{1}{4}$ inch, $1\frac{5}{8}$ inch, $\frac{1}{2}$ inch, $1\frac{1}{2}$ inch, $\frac{1}{4}$ inch, $2\frac{1}{4}$ inches. The seal was here twice lost, and came very near it twice more.

(7) "The vent pipe, one foot long, was then increased to three inches diameter. Ten pails were emptied, with loss of water as follows, viz.: $\frac{1}{2}$ inch, $\frac{5}{8}$ inch, $\frac{7}{8}$ inch, $\frac{3}{4}$ inch, $1\frac{1}{2}$ inch, 1 inch, $\frac{3}{4}$ inch, $\frac{1}{4}$ inch, $\frac{3}{4}$ inch, $1\frac{1}{2}$ inch. The seal was not lost now, though coming within $\frac{5}{8}$ inch of it.

"In all these three last experiments, where the vent was in the crown

of the trap, the water was seen to dash up into the vent pipe, and spill over the top of it, even when a foot long and three inches diameter. When it receded, a portion of this water dropped back into the trap, and just sufficed to keep its seal when the vent was three inches in diameter, but not when smaller. The loss of water was plainly attributable to the *momentum* of the stream when passing through the trap, quite as much as to the air draft. This was proved by varying the direction in which the water was poured into the hopper. The above records are all the results of pouring it in at the side of the hopper *opposite the trap*, so that the velocity of the water acquired in its fall from the pail through the hopper was not impaired by such an abrupt change of direction, when striking the bottom of the trap, as it would be if the pail were applied either directly over the trap, or half-way between this and the former position. Moreover, there was no strainer at the base of the hopper, to break the momentum, the hopper being of the form formerly much used for water-closets.

(8) "In order to eliminate, in some degree, the effect of this momentum, the same experiments were tried with another form of hopper, suitable for a water-closet, and having its trap *above* the floor, such as is marked 'Water-closet No. 1' on the plate. The distance through which the water had to fall from the edge of the hopper to the bottom of the trap was thus reduced by ten inches. The trap had a seal of two inches, and was first tried with no vent in it. It discharged directly into a patent Y-branch with expansion at top, devised for the purpose of preventing siphoning. Nine pailfuls were emptied with a lowering of the trap water as follows, viz.: 1 inch, $\frac{1}{2}$ inch, $1\frac{5}{8}$ inch, 2 inches, $\frac{1}{4}$ inch, nothing, $2\frac{1}{8}$ inches, $1\frac{7}{8}$ inch, $2\frac{1}{4}$ inches, losing the seal three times in the nine. Another trial, under similar conditions, showed a loss of the seal three times in five.

(9) "A vent pipe, one foot long, and one and a half inch diameter, was then applied at the crown of the trap. Ten pailfuls were emptied to favor a loss of water by momentum, but no appreciable loss of water occurred.

"In order to eliminate from the last two experiments the possible effect of the offset in the main pipe directly under the connection of this branch, the same experiment was tried on the floor below, at 'Water-closet No. 2,' with essentially similar results, indicating that the offset did not modify the case perceptibly.

(10) "The effect of excessive lengths of vent pipe was experimented on with the result that, under conditions which indicated perfect security, with a pipe one foot long and one and a half inch diameter, on a four-inch trap, a coil of pipe fifty feet long coupled to the vent rendered it inefficient once in eight trials, the trap having two inches seal being siphoned in this case, and lost one inch of water three other times out of the eight.

"In another case where a short vent of one inch diameter seemed to be quite efficient, a coil of one-inch pipe with a length of twenty-eight and a half feet being coupled to it, rendered the vent of apparently little use, for the trap lost its seal at every trial.

(11) "In order to test the effect of a partial closing of the top of the soil pipe, a piece of pasteboard was laid over it, having a hole of only two inches diameter. Such a stricture is often produced above the roofs of buildings in cold climates by the formation of ice through condensation of the vapor of water which rises with the air through the soil pipes. It was found that it was much more difficult to retain the water in the traps in all cases under this condition, except where special vents were applied

to the traps themselves. In such cases the stricture above described, at the top of the soil pipe, seemed to produce no appreciable effect.

"We will next consider the loss of water in traps by the flow past them from above through the main into which they discharge.

"C. *Experiments with a Two-inch Waste-pipe, open at the Top.*

(1) "A trap of one and a half inch calibre of S-form, having four and one-fourth inches depth of seal, and having strips of glass inserted in its sides where the lead was removed, was applied at the branch marked G on the plate. The plug connecting with the two-inch waste was then drawn from the bath-tub on the floor above and the water allowed to run a few seconds. The water in the trap was found to have fallen 4½ inches. The next trial destroyed the water seal with a flow of ten seconds. A third trial produced the same result in four seconds.

"Five pailfuls of water were then poured in succession into the hopper at (e) on the third floor, with this result: The seal was twice entirely lost, and for three times the water was lowered 4½ inches, leaving only ⅛ inch seal.

(2) "This deep trap was then removed and an S-trap of same calibre applied in its place, with glass strips in its sides and a vent-hole one inch in diameter on its crown. Five pailfuls in succession were poured into the hopper above with no perceptible loss of water in this trap. Its water was agitated less than ⅛ inch.

(3) "The vent-hole was then half covered, and the experiment repeated with scarce a perceptible loss of water.

(4) "The vent-hole being wide open, the bath plug was withdrawn for twenty seconds. The water in the trap oscillated about ¼ inch, but was not lowered perceptibly.

(5) "This trap was removed and a Cudell trap substituted, such as is shown at S on the plate, with no air-vent in it. The bath plug above was raised for ten seconds, and the trap was found to have lost all its water. The plug was raised again twice for six seconds each time, and the trap twice again completely lost its water seal. Three pailfuls of water were emptied at the hopper in succession, and the trap lost its water seal each time.

(6) "This trap was removed and a Bower's trap substituted without special air vent, such as is shown at T on the plate. The plug was drawn from the bath above for fifteen seconds, and the trap was found to have lost 1½ inch of water, leaving about $\frac{3}{16}$ inch water seal. A second and a third trial of the same flow without refilling the trap, left less than $\frac{1}{16}$ inch of seal. Air was now readily sucked up through the trap by the mouth, in spite of its ball, which was new and clean. On filling the trap again and pouring a pailful into the hopper above, ⅜ inch seal was left. Two pails more, without first filling the trap, left about ¼ inch seal. The hopper was then filled by a pailful of water and discharged by lifting a plunger, and ¼ inch seal was left.

(7) "This trap was replaced by an Adee trap, such as is shown at Q on the plate, having 1⅛ inch seal. The flow from the bath above destroyed the seal in ten seconds for three trials in succession. Three successive pailfuls of water emptied at the hopper above left from $\frac{1}{16}$ to ⅛ inch seal after each.

"D. *Experiments with a Four-inch Waste or Soil-pipe, open at the Top.*

(1) "The four-inch trap at (g) on the plate, having two inches depth of seal, was observed. The vent-hole in the trap was at first closed. The discharge of a pailful of water at the hopper above lowered the trap water $\frac{7}{16}$ inch. The simultaneous discharge of the hopper and water-closet above lowered the trap water $2\frac{3}{16}$ inches, destroying the seal. The discharge of the hopper while the bath waste was flowing, lowered the trap water $2\frac{1}{16}$ inches and broke the seal. The discharge of the water-closet above, six times in succession, lowered the trap water respectively $\frac{1}{16}$ inch, $1\frac{1}{8}$ inch, $\frac{1}{2}$ inch, $1\frac{1}{4}$ inch, $\frac{7}{8}$ inch, $1\frac{1}{2}$ inch. The discharge of the water-closet, and hopper, and bath together, six times in succession, lowered the trap water from $2\frac{5}{16}$ inches to $2\frac{1}{2}$ inches, destroying the seal every time.

(2) "The vent-hole, $1\frac{1}{2}$ inch diameter, in this trap was then opened, the water-closet, hopper, and bath were then discharged simultaneously ten times in succession, with the loss of only $\frac{1}{8}$ inch of water from the trap in any instance.

(3) "This same experiment was twice repeated with the top of the soil-pipe closed, showing a loss of only $\frac{3}{8}$ inch of water from the trap in any case.

(4) "The water in the large trap at (J) on the plate, was observed with discharges of water from above, similar to those noted in the last three experiments, and with results so essentially similar that they are hardly worth reciting in detail.

(5) "An S-trap of $1\frac{1}{2}$ inch calibre and $1\frac{1}{2}$ inch depth of seal was attached to the branch marked J on the plate, on the second floor, with no vent in the trap. Water was discharged ten times in succession from the bath and water-closet above, for periods of from five to eight seconds each. The trap was unsealed four times and lost from $\frac{5}{8}$ inch to $1\frac{1}{8}$ inch of water at the other six trials.

(6) "The same experiment was repeated with an opening in the crown of the trap $1\frac{1}{2}$ inch diameter, with loss of water in the trap as follows: $\frac{1}{4}$ inch, few drops, $\frac{1}{8}$ inch, $\frac{3}{16}$ inch twice, few drops twice, $\frac{1}{16}$ twice, few drops.

(7) "A Bower's trap was attached at the same place, with no air-vent in it. The water-closet above was discharged while the bath waste was running ten times successively. The trap lost its water seal four times and lost at the other six trials from $\frac{1}{4}$ inch to $1\frac{1}{4}$ inch of water.

(8) "A Cudell trap was then substituted at the same branch marked J. The water-closet was discharged above while the bath waste was flowing ten times in succession. Nine times the water was all taken out of the trap and once there was about $\frac{1}{8}$ inch left.

(9) "A round trap, having $2\frac{1}{2}$ inches seal, as shown at R, was then substituted at this branch J. The discharge of Water-closet No. 1 lowered its water $\frac{1}{8}$ inch. The discharge of the same closet and the hopper together lowered it $\frac{3}{4}$ inch. Further trials of this trap showed that the discharge of the largest volumes of water possible at once from the three fixtures above could not unseal it, for though quantities of air were drawn through it, as seen through the glass in its sides, there was so much space for the air to pass by the water that the seal always remained efficient. It would be instructive to try such a trap after it had been encumbered with grease and other rubbish, as is often the case, and where this space for air to pass by the water might perhaps not be found.

"Before deducing any rules for practice from these experiments, it must be remembered that they were made with new, clean, enamelled pipes, while those in ordinary use are always more or less encumbered with scales and tubercles of rust, and with the grease and slimy coating deposited by the sewage. Even in vertical pipes such collections often reduce the diameter $\frac{1}{4}$ of an inch, thereby reducing the sectional area of a four-inch pipe about $12\frac{1}{2}$ per cent. and of a two-inch pipe about 23 per cent.; while in sloping waste pipes, like those under wash-trays and bath-tubs, the accumulation of solid matter from the sewage often amounts to a permanent occupation of one-half or three-fourths of the whole section.

"It needs but a casual reference to the above experiments to prove what is generally known and admitted already, that the difficulty of retaining water in traps increases as the size of the waste pipe decreases, so that we must expect, with pipes that have been used for any considerable period, much more tendency in the traps to lose their seal by unequal air pressure than in the cases recorded above under conditions which are otherwise similar. Two causes combine to produce this result, viz.: The smaller pipe is filled by a less volume of water, which acts like a piston as it passes downward, while the air that follows from the vents above finds in the smaller pipes less room to flow in and a consequent increase of friction, which, by impairing its velocity, leaves the unequal pressure which we complain of.

"Moreover, there are various conditions affecting the stability of water in traps which may not have been foreseen and covered in these experiments. The various results actually arising when repeating the same experiment under conditions apparently identical show how unsafe it is to make general deductions from a small number of trials.

"These variations may be accounted for in part by the various paths taken by the water when poured at different times from one vessel to another, and when running down a vertical pipe. There is always a tendency to follow a spiral course. When such a twist is given to the water at the start, in the hopper, it generally checks the velocity so as to prevent the unsealing of the trap attached to it. When occurring in the vertical pipe, as it passes by the connections of other branches, it makes a great difference whether the path of the spiral happens to hit exactly across the opening of such a branch, or happens to pass on the other side of the main.

"It would require much more time and labor than we have spent upon the subject to exhaust any considerable part of such possible variations which are likely to occur in daily practice. The relative size and position of the different branches, the quantities of water passing through them, and the endless number of combinations of flow from different fixtures which occur daily in any large house or hotel; all tend to vary the result to a degree which should induce a prudent man to allow a large margin on the side of safety. The risks are known to be considerable in case of exposure of untrapped drains in dwellings. It should also be remembered in this connection that we live in a climate where artificial heating of houses, warm chimneys, and the careful closing of wall and window cracks, combine to produce a decided pressure of air from without the house inward, acting through all our house-drains, through several successive months every year, and that we know of no method as yet so satisfactory for resisting this pressure as the use of the water-sealed trap. We are aware that a large number of ingenious devices have been introduced to supplement the water-seal by mechanical valves with moving cups, balls, and flaps, but we

have never seen one of these devices which could be relied upon to shut out air after the apparatus had been used and defiled for a few months by a flow of ordinary house-drainage, whether from laundry, kitchen, or lavatory.

Conclusions and Recommendations.

"When hoppers are used for the emptying of slops, having a trap below the flow, it is difficult to preserve the seal in the ordinary form of S-trap even by a vent-pipe attached thereto. The momentum of the falling water helps to do the mischief. An abrupt change of direction may impair this momentum. But since it is manifestly useless to try to control the direction in which the water is emptied into the hopper, we should endeavor to check it by the form of the apparatus. . . .

"When a short hopper is used for emptying slops, with a trap above the floor, though the momentum of the falling water is considerably reduced by the diminished distance through which the water falls from the pail to the trap, there is still no security for keeping the water in the trap, unless supplied by a special air-vent. This should be at least one and a half inch in diameter, if more than a few feet in length, and even larger if passing to other floors above.

"Other forms of traps which, like the one referred to in the Experiment D (9), might save and retain their water by means of a lateral expansion of their basins, are objectionable, owing to the amount of filth which they retain, subject to decomposition. The ordinary S trap alone, with ample air-vent, is therefore recommended for use under water-closets, and also for all other fixtures where its proper ventilation can be secured within reasonable limits of expense.

"The above precautions are of more importance and should be observed with greater care when waste-pipes are used of smaller size than four inches to carry the flow for more than one or two feet in distance.

"The difficulties arising in such conditions are illustrated by the Experiments A and C above noted.

"Whenever branch inlets are connected to a line of waste or soil pipe that is vertical or approaching that direction, above which branches other fixtures are used for discharging water into the same main, there is great risk of losing the water from the traps of such branches whenever the upper fixtures are used.

"No form of trap without special air-vent has come to our notice which is not likely to lose its water-seal under such circumstances, even when the top of the soil or waste pipe is open, except those which, like the round trap, are objectionable for retaining filth. This form of trap shown at R on the plate is largely used about Boston. They would be safe if always tight, but have a joint for cleaning purposes which is often leaky. Experts differ according to their individual experiences as to their liability to become choked with filth in their upper part.[1]

"The best and most simple remedy for the siphoning of traps in most cases is undoubtedly to be found in the introduction of air at the normal pressure at the crown of the trap. The reason for preferring the crown to any other place can be found in the above record, see Experiment B (2) (3) (4) (5) (6) (7).

[1] The writer has used a modification of this form of trap with a round bottom, as shown on the cut Fig. 117, which is less likely to retain filth than those with a flat base.

"No definite rules can be given for the size and length of vent-pipes. Yet it may be said that it is not safe to trust to a vent-pipe of less size than that of the trap it is to serve until we get above two inches in diameter, except they be of only a few feet in length before they join those of a larger size. The greater efficacy of a vent applied directly at the trap, as compared with the air-supply through the top of the main soil-pipe, is shown by Experiments B (11) and D (2) and (3).



FIG. 117.

"There is still another risk arising from change of air pressure in drains, besides that of siphoning traps. The latter is the result of lack of pressure, while an excess of pressure is also to be avoided. The following experiment illustrates this point: It is applicable to all house-drains having an exterior main trap, or discharging into a cesspool at a point below the water-line by a dipping inlet pipe, as is often done for the sake of checking the back flow of gas from the cesspool. The trap at the lower end of the system, at the point marked V on the plate, was filled with water, and the air inlet just above it was capped. The trap at (n) on the basement floor was then filled with water, and a pailful emptied at the hopper on the third floor, connecting to the four-inch main. The air was so compressed ahead of the falling water that it was forcibly blown out at the trap (n), carrying with it a good deal of water, showing how foul air from a drain can thus be ejected into the apartments of a house in considerable volumes. The fixture connected to such a trap may generally be able to collect and restore to the trap enough of the water expelled to save its seal, and thus no apparent defect would be found, unless the blowing out of the foul air through the trap happened to attract attention.

"On removing the cap from the air-hole near V, and repeating the experiment, no apparent disturbance followed in the trap (n).

"Another experiment was tried to illustrate the retarding effect of friction and the consequent change of pressure in small waste-pipes, viz.: An ordinary S trap of 1½ inch seal, and 1½ inch calibre was attached in the basement to the branch marked U of the two inch waste pipe. This represents a combination frequently occurring in the waste-pipes of pantry sinks. This trap was filled with water, and a pailful emptied into the two-inch waste on the third floor above. The air was forcibly blown out of the trap at U by the compression of air ahead of the descending charge, even when the four-inch air-hole near V was open in the main below. This result was plainly due to the friction caused by the air rushing through the abrupt bend at the connection marked Z. It shows the risk incurred by branching small waste-pipes into one another when used on several floors, and the impropriety of using a quarter bend and T branch at Z, instead of a Y branch.

"Though condemned by English authorities, it is doubtless a safer way to connect the waste-pipes of baths, bowls, etc., used on upper floors, directly to the large soil-pipe by Y-branches, as near as practicable to the fixtures drained, than to erect long lines of smaller-sized wastes separately for such purposes. Certainly the larger the pipe, the less is the risk of any abnormal air-pressure occurring by its use so long as the wastes are not likely to become encumbered seriously by accretion of solid matter.

"The provision of separate wastes for baths, etc., all the way to the basement is considered important in England, probably because of a dislike to make inlets in the soil-pipe used for water-closets. But the risks arising from the use of a small-sized waste through such distances are thus proved to be considerable, and should not be ignored; while those arising from the common use of a four or five inch pipe for water-closet and general refuse water on several floors may have been overrated in England."

Grease Interceptors.

Wherever kitchen and pantry sink drains which are used for the discharge of water from the washing of table dishes cannot be provided with a very rapid fall, the congealing of the grease is likely to form a deposit on the inside of the drain which often obstructs it entirely.

The use of a larger pipe does not remedy the difficulty, for the quantity is often sufficient to fill a drain eighteen inches in diameter in a few months. The only efficient remedy is to apply an intercepting tank, as near the sink as possible, so as to avoid the filling of the drain with grease between these receptacles and the sink. The best material of which to construct the tank is Portland cement, mixed with clean sharp sand, and moulded in forms as for large sewer pipes. They are now constructed for the purpose in Boston, with a bowl-shaped bottom inside and flat bottom outside, moulded in one or two pieces, to accommodate the desired depth below the surface, and fitted with an iron flange and cover. The outlet pipe is made of a four-inch soil-pipe T branch, which admits of being cleaned out from above.

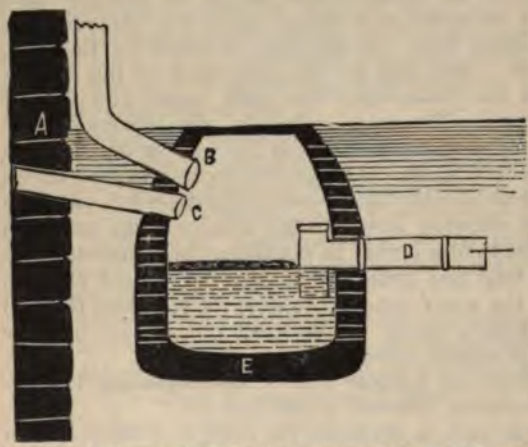


Fig. 118.—A, House-wall. B, Ventilation Pipe. C, Inlet. D, Outlet.

The grease then congeals and floats on the surface, and can be removed when convenient. This arrangement is shown in Fig. 118. The outlet for water being immersed several inches below the surface, the water is allowed to flow off, while the grease accumulates on the top of the standing water.

Importance of Simplicity.

One of the most frequent faults to be found in the planning of the plumbing and drainage of American houses is in the multiplication of fixtures for the convenience of the inmates, scattered without consideration and without sufficient reason all about the house. It is difficult to render such arrangements safe without a large outlay in safeguards, and even then an unnecessary risk is incurred by lack of simplicity. It is important to

limit these conveniences to the immediate vicinity of the soil-pipe, and to avoid all drain or waste pipes passing in a nearly horizontal direction. A common error is illustrated by the annexed cut (Fig. 119), where a wash-bowl waste is connected with a water-closet trap, several feet distant, by a

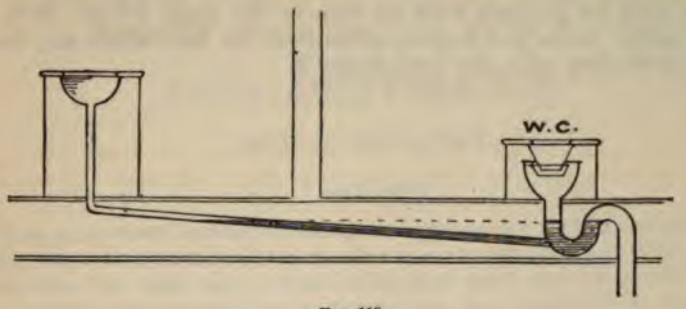


FIG. 119.

pipe under the floor, difficult of access, and so nearly horizontal as to insure its being soon filled by a deposit of slimy filth, through which the water finds its way slowly and with difficulty. Such an arrangement can never be satisfactory. The bowl should be placed close to the closet, and should drain into the soil-pipe by a separate branch below the water-closet trap, having a special trap under the bowl itself.

One of the most complicated and objectionable pieces of apparatus is the old-fashioned and largely used "pan" water-closet, which is now, however, being generally superseded by various better patterns. Nearly all the new devices are better that the pan closet, which is by all means to be avoided.

Among the best forms for general use are the simple hoppers with traps above the floor. This position for the trap brings the water it contains in plain sight, and reduces to a minimum the surface likely to be soiled above the trap-water. Moreover, it diminishes the chance of loss of the trap-water by momentum, an important item. Where to be used by servants, children, or artisans, the water-supply should be made automatic, and metered by a waste-saving apparatus, as illustrated on the annexed cut (see Fig. 120). The weight of the person on the seat is thus made to lift the valve in the bottom of the tank, which should be placed directly over the closet, and thereby fill the service-box beneath. When the weight is removed from the seat this valve closes and the lower one opens, dis-

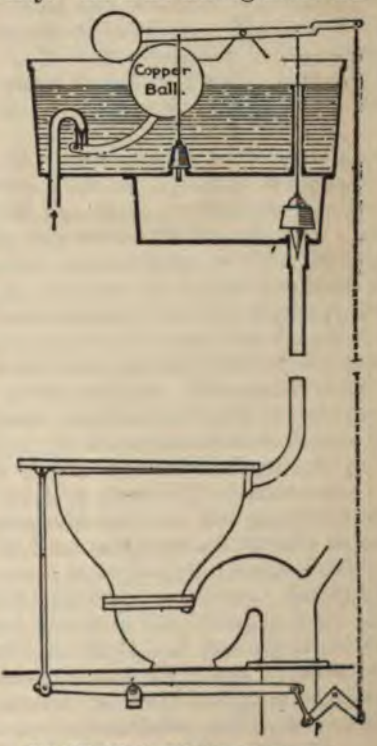


FIG. 120.—Tank with Automatic Supply.

charging an ample and definite quantity of water with a sudden dash, which expels all the contents of the trap below. The ordinary method of flushing hopper closets by a faucet is a miserable makeshift. Even if the faucet is left open for half the time, with the consequent waste of several hundreds of gallons of water per hour, the object sought is not gained, for such a driblet does not properly flush the trap or the drain below. It is a perfectly useless waste, and leaves undisturbed the filth which may have collected in the trap or in the drain below it.

FOOD ADULTERATION.

By E. G. LOVE, Ph.D.

Legislation.

The first movement toward securing comprehensive legislation against the adulteration of foods and drugs in this country was made in 1879. A competition for the best essay on the subject of food and drug adulteration, with drafts of suitable bills for its prevention, was instituted by the *Sanitary Engineer*, under the direction of the National Board of Trade. Prizes amounting to $1,000 were offered for the best essays, which sum was placed at the disposal of the Board by Mr. F. B. Thurber, one of its members. The committee of award being also required by the terms of the competition to frame laws suitable for State and National enactment, was selected as representing the different interests involved. The Committee was composed as follows: Dr. John S. Billings, Surgeon United States Army; Professor C. F. Chandler, President Board of Health, New York; Ex-Chancellor B. Williamson, Elizabeth, N. J.; A. H. Hardy, Esq., Boston; John A. Gano, Esq., Cincinnati.

In October, 1880, several essays, with drafts of laws were sent in, and on the 29th of that month the committee made its report to the Board of Trade. In none of the essays submitted was there any evidence to show that dangerous adulterations existed to any extent in this country. This fact was corroborated by several extensive examinations of food products made about that time, and proved most conclusively to the minds of the Committee that there was no foundation whatever for the statements so frequently made by ignorant persons that our food supply was dangerously adulterated. This same conclusion had been already reached by many persons who had made special study of the subject. The publication of wild and fanciful stories as to poisonous substances found in articles of food, while it may give a certain notoriety to the writer of such fiction, can result only in needlessly alarming the public and in detriment to many commercial interests, and it should be most emphatically condemned.

If the substances generally used as adulterants are not positively dangerous to health, then the question of food adulteration should be considered, as stated in the Committee's report, more from the commercial than from the sanitary standpoint. The Committee also expressed the opinion that there was more danger to life and health in this country from adulterated drugs than there was from adulterated food, and that any legislation which aimed to correct the one must also deal with the other. This suggestion was very pertinent at that time, inasmuch as a bill had been previously introduced in Congress, which was entirely unsuitable and inadequate for the purpose, and which, moreover, referred only to articles of food.

If the adulteration of food is considered simply as a commercial matter, the execution of laws enacted for its prevention would naturally devolve

upon a commercial rather than upon a sanitary organization. Such is the case in Canada, where the enforcement of the Adulteration Act is placed upon the Department of Inland Revenue. Inasmuch, however, as the individual States in this country have no similar department, and as the proposed legislation should include drugs as well as food, it was thought expedient by the committee to entrust the execution of the laws for this object to the State Boards of Health; and where such boards do not exist it was suggested that they be created by independent legislation.

"The questions involved are in a high degree technical and require special training in those charged with administering the law;" but it was the opinion of the committee that the existence of such health authorities might be taken for granted.

While the competition did not result in furnishing the draft of an act which met the views of the committee, many suggestions were obtained, and the committee subsequently presented to the Board of Trade drafts of National and State acts. These drafts, together with the committee's report, were approved by the Board of Trade on December 15, 1880, and resolutions were adopted directing the President and Secretary of the Board to transmit to the United States Senate and House of Representatives copies of the report of the committee and of the draft of a national act, requesting in behalf of the Board the passage of the same.

Copies of the report and drafts of acts were also sent to the State Boards of Trade with the request that they use their influence to secure the desired legislation. The bill introduced in Congress was subsequently modified by excluding all reference to inter-State traffic, and by the substitution of the "Secretary of the Treasury" for the "National Board of Health." In this form it was reported by the Committee on Commerce of the House of Representatives, but up to the present time it has not become a law.

In 1881, three States—New Jersey, New York, and Michigan—passed laws to prevent the adulteration of food and drugs.

New Jersey.—In New Jersey the law was approved March 25th, and went into effect thirty days later. The bill, as passed, was the same as that recommended by the National Board of Trade for State enactment; and its provisions correspond in general with those contained in the bill introduced in Congress. The enforcement of the law was placed in the hands of the State Board of Health, and soon after its passage the board appointed eight persons as a "Council of Analysts and Chemists." Circulars were sent to the local boards of health, and to physicians and others, asking for any information in their possession of cases of poisoning or injury to health by the use of improperly prepared or adulterated foods and drugs. A series of examinations was commenced by the analysts, the results of which were subsequently published.[1] The Legislature which passed the law rendered its enforcement practically inoperative by the appropriation of only $500 for carrying out its provisions. Early in 1883 the law was amended in several important particulars. One section of the amended act, referring to the disposal of penalties, reads: "In case of any suit not otherwise provided for, the penalty shall be paid to the person bringing the suit." This is an unwise provision, as it encourages prosecutions for violations of the law, with no other object than the pocketing of the penalty by private individuals. The report of the Board of Trade committee, already referred to, distinctly says that "under no circum-

[1] Fifth Annual Report of the Board of Health of New Jersey, 1881.

stances should fees or moieties to informers be allowed." Another section gives power to any officer of any local board of health to inspect any article of food or drugs, whether offered for sale, "or whether in transit or otherwise." As local boards of health are liable to have officers who are in no way qualified for such inspections, and who might make them for the sole purpose of obtaining the fine imposed, in case of conviction, it is very clear that this section gives too much power to individuals; and it is altogether likely that sooner or later cases will arise under this section which will bring disrepute upon the law and great annoyance to commercial interests. The amendment is to be commended in one particular, in that it allows the Board of Health to expend $1,000 annually in carrying out the provisions of the act.

It has been stated by one of its officers that it is not the intention of the Board of Health "to chase every commercial fraud," but "to look after adulterations harmful to health." If this be true, the commercial interests, which were largely considered by those who drafted the original law, will receive little protection in New Jersey; and the consumers and honest tradesmen, in whose interest the law was presumably enacted, must look elsewhere for that protection from commercial frauds which they had every reason to expect would be furnished by the State Board of Health.

The first case brought to trial under the New Jersey law was in May last, in which a person was convicted of selling skimmed milk. So far as we know, this is the only case up to the present time.

New York.—The legislation against food and drug adulteration in New York commenced by the introduction of a bill in the Legislature during the winter of 1880–81. The bill was passed and became law on June 2, 1881; but it did not go into effect until ninety days later. The bill[1] was that recommended by the Board of Trade, and placed the enforcement of the act upon the State Board of Health. The sum of $10,000 was appropriated for carrying out its provisions.

It is a fact worthy of note here that the passage of this law was largely due to the support and co-operation of the leading food and drug manufacturers and dealers.

The first step taken by the Board was the appointment of eight experts, including chemists and pharmacists, who were asked to make examinations of the foods and drugs sold in the State, for the purpose of ascertaining to what extent adulteration existed, and also to determine the nature of the adulterants employed. The supervision of this work was placed in the hands of the Sanitary Committee of the Board. To each analyst was assigned a group of foods or drugs for examination, it being the opinion of the committee that more could be accomplished in such preliminary work in this way than by giving to each one all the samples from a certain locality. The samples were collected by two inspectors.

The reports[2] of these examinations fully corroborated the existing evidence, that most of the adulterations of food were such as to affect the pocket more than the health. Unwholesome adulterants were found, but *none* which were really poisonous.

On the completion of this preliminary work, the Board divided the State into three districts, and appointed four public analysts and one inspector, to each of whom a fixed salary was paid in lieu of all fees.

[1] A copy of this act will be found at the end of this article.

[2] See Second Annual Report State Board of Health of New York, 1882. Abstracts of the same, The San. Eng., vol. v., March, 1882.

The actual work of the Board in the enforcement of the adulteration law commenced in the summer of 1882. The report of the Sanitary Committee for 1882 shows that up to the close of the year 286 samples of foods and drugs had been submitted to the public analyists for examination, of which 194 had been reported upon. Of 119 samples of food, 50 were found adulterated; while of 75 samples of drugs, 32 were adulterated. During December, 1882, prosecutions were commenced in twenty-four cases for violations of the law. These included seventeen cases for selling cream of tartar adulterated with terra alba, starch, etc., to the extent of from thirty-seven per cent. to ninety-five per cent.; two cases of coffee adulterated with chicory and burnt peas; four cases of mustard adulterated with from forty per cent. to seventy-one per cent. of flour; and one of precipitated sulphur, containing thirty per cent. of sulphate of lime. One of the cream of tartar and one of the mustard cases were made test cases and convictions secured in both instances. The defendants in the other mustard cases and in the coffee cases pleaded guilty and paid the penalty.

The cream of tartar case was appealed, and the decision reserved, principally on the ground that criminal intent had not been proved. The Board of Health did not carry this case to a higher court, and the other cream of tartar cases were never brought to trial. The action of the Board, however, resulted in calling public attention to the fact that adulteration existed, and also in very materially improving the quality of certain articles of food, as was shown by subsequent examinations. As another result, the Board of Health held a conference with the manufacturers, for the purpose of ascertaining their views relative to the sale of mixtures, such as mustard and flour, coffee and chicory, etc. It was the opinion of the manufacturers present at this conference that the components of a mixture, as well as the percentage of the principal or characteristic constituent, should be printed upon the label; but not the percentage of each constituent present. The Board subsequently passed resolutions permitting the sale of mixtures of mustard and coffee, which resolutions received the Governor's approval in March, 1883, and so became law.[1]

The action of the Board of Health in instituting proceedings against the retail grocer instead of the wholesale dealer or manufacturer was somewhat criticised, as being of the nature of persecution, and on the further ground that the grocer, having purchased his merchandise in good faith, supposed it was unadulterated. This, of course, is a very important matter in the enforcement of any food adulteration law. Legal proceedings should be brought against the manufacturer, if possible, but failing in this, against the wholesale merchant, or lastly against the retail dealer, who may or may not know the exact nature of the goods he sells. The manufacturer is the most responsible, and should first be brought to account; but this does not free the retailer from responsibility or exempt him from prosecution in case he violates the law. It is often impossible to reach the manufacturer except through the retail dealer, and while the Board of Health would gladly prosecute the former, such a course is, as a rule, impossible, from the fact that the retailer is unwilling to testify against the manufacturer. To purchase an article in very small quantities from the manufacturer or wholesale merchant, if possible at all, would arouse suspicion, and doubtless result in the purchaser getting the genuine and not the adulterated article. The Board can hardly be expected

[1] A copy of these resolutions will be found at the end of this article.

to buy a barrel of flour or a firkin of butter in order to get a few ounces for analysis.

The prosecution of the retailer, therefore, is in the majority of cases, the only practicable plan for those charged with the enforcement of the law, unless the retailer himself will become a witness for the prosecution.

The public have a right to assume that the merchant who offers goods for sale knows the nature of the goods he sells. It is a part of his business. Some allowance must, of course, be made in the case of articles which require chemical examination to reveal their nature; but most grocers would be very indignant if told that they could not tell whether mustard was one-half flour, or pepper two-thirds sawdust. Many will assert that they can distinguish genuine butter from oleomargarine by the taste, and yet, if prosecuted for selling the latter for the former, would say, or allow it to be said for them, that they did not know it was oleomargarine.

The retail grocer can always protect himself by purchasing his stock of reputable dealers, or secure himself against pecuniary loss by demanding a written guarantee as to the quality of the goods he buys, and thus avoid all probability of prosecution.

As to proving criminal intent it is absolutely impossible to do so in very many cases which might arise in the enforcement of an adulteration law, notwithstanding that the prosecution might be morally certain that the dealer knew just what he was selling. Judges Cockburn and Blackburn have both decided, in adulteration cases brought before the Court of Queen's Bench, that it was not necessary to prove criminal intent in such prosecutions, and that the grocer is supposed to know what he sells.

These remarks relative to the enforcement of the Food Adulteration Act in the State of New York will apply, to a greater or less extent, in States where existing or future legislation may render similar prosecutions essential.

The operation of the law in New York State has demonstrated that its enforcement should be placed in the hands of one person, to whom the Board of Health should give sufficient power to enable him to act promptly in an emergency. Moreover, this work involves a certain knowledge of technical and analytical chemistry for its intelligent and energetic performance. The director of the work should be qualified to say what kind of an analysis is necessary, and be able to judge of the value of an analysis with a view to prosecution; and he should also be so thoroughly imbued with the importance of the work, that he will perform the duties imposed with promptness and energy. Anything short of this will result in the accomplishment of little practical good in the suppression of adulteration. It is also important that counsel specially qualified for the work be employed to conduct prosecutions.

The funds appropriated by the last Legislature for enforcing the Adulteration Act were withheld in consequence of the Governor's veto. This partly accounts for the apparent inactivity of the Board of Health in carrying out the provisions of the law at the present time.

The enforcement of the food law may be said to have passed the experimental stage in New York State, and with energy, discretion, and the needed funds it can be, and should be felt in the suppression of adulteration.

Michigan.—In June, 1881, Michigan passed a law to prevent the adulteration of food, drink, and medicine. The act differs entirely from that passed in New York State, and recommended by the Board of Trade. The first defect noticeable in the law is that no one in particular is entrusted

with its enforcement. It is made the duty of the prosecuting attorneys of the State to appear for the people, but no one is likely to commence proceedings for violations of the law, unless it be some injured or aggrieved individual. Moreover the law does not contain any definition of adulteration, and provides for no standards of purity. It is evidently aimed more especially at glucose and oleomargarine, as these are the only substances mentioned in the act. The law should be so comprehensive as to avoid all necessity for the mention of any particular articles of food.

The statutes of very many States contain laws which were directed against some one article of consumption, but which, for want of some provision for their enforcement, have long been so much dead matter. We have heard of no cases being brought under this act, and doubt whether Michigan will ever be any better off for its passage.

Massachusetts.—In May, 1882, the State of Massachusetts, through the efforts of its Board of Health, Lunacy, and Charity, passed a law for the prevention of food and drug adulteration. This law is substantially the same as that passed in New York State. Its enforcement is placed in the hands of the State Board of Health, and the law empowers the Board to expend annually an amount not exceeding $3,000 for the purpose of carrying out its provisions.

Soon after the passage of the act the Board appointed two analysts, one for the examinations of foods, and the other for that of drugs. Regulations were also adopted for the guidance of the analysts in procuring and examining samples.

At the meeting of the Legislature next following the passage of the act, the law was amended by increasing the annual appropriation from $3,000 to $5,000, and providing that two-fifths of this amount should be annually expended in the enforcement of the law against the adulteration of milk. Under this provision the Board have appointed two additional analysts, whose duties will be confined especially to the examination of milk.

Prosecutions have been already commenced for violation of the law, and there seems to be every probability that the enforcement of the law will be a success.

Louisiana.—The State of Louisiana passed a law in July, 1882, prohibiting the sale of adulterated foods and drugs. The act bears some slight resemblance to that recommended by the Board of Trade, and adopted in several States; but the changes that have been made are such as will seriously affect its efficiency if its enforcement is ever attempted. The definitions of "food" and "drug" are omitted, and the definition of adulteration is incomplete. No provision is made for drugs not mentioned in the "United States Pharmacopœia." A part of one section reads as follows: "No person shall manufacture, sell, or offer for sale within this State any drugs, groceries, such as sugar, coffee, tea, butter, cheese, or any other article to be consumed as food or drink, unless the package when sold at wholesale, or the package from which it is taken when sold at retail, be stamped in plain large letters showing the true quality and kind of the articles sold. . . ." There is a fine of twenty-five dollars for violating this provision. As this section reads, the clause "or the package from which it is taken when sold at retail" refers to the wholesale package, and consequently no provision is made for stamping the nature of the article upon the package which the consumer who buys at retail receives. If it was intended that the packages sold at retail should be stamped under all circumstances, as indicated in the law, we should still object to it on the ground that the law should take it for granted that the consumer

was getting the genuine article, unless informed to the contrary. If the retailer gives oleomargarine when asked for butter, or chicory when asked for coffee, he should be required to furnish such information, in some form, to the purchaser; but to require the honest grocer to stamp every article he sells as pure, appears like a needless tax upon trade.

Another section provides that the State Board of Health shall analyze any drugs or foods it may think necessary, and in case any such article is deleterious to the public health, it shall publish the results of the analysis and "warn the public against its consumption."

This law evidently does not contemplate any general supervision and examination of foods and drugs.

The foregoing gives some general idea of what has been accomplished so far in suppressing the adulteration of foods and drugs in this country. Many States, having as yet no general adulteration law, have passed certain acts aimed at the suppression of adulteration in particular articles. Without attempting to mention these in detail, it may be said that as the majority of them make no provision for enforcing the law nothing further is heard of them.

Adulteration.

The limits of this paper will permit only a few remarks on the adulteration of some of the more important articles of food in this country.

Milk.—Of the more important articles of human food, none is more generally adulterated than milk; and at the same time greater efforts have been made to prevent the adulteration of milk than of any other food. The reason for such efforts is apparent in the fact that all recognize milk as a very important article of food, both for young and old; and where it forms so prominent an element in the food of infants it is especially important that it be obtained pure and unadulterated.

Many States which have no general adulteration law have passed special laws to prevent the adulteration of milk; and where no State legislation existed Boards of Health have taken up the question, and have done much to stop the fraud. For certain reasons local Boards of Health are in a better position to act than State Boards; and in most of our larger cities there are one or more milk inspectors, usually under the control of the Health Board, where such an organization exists. The perishable nature of milk makes it necessary that its examination be attended to immediately. This can be done by local authorities, whereas, if the milk be sent to a distance for examination by an officer of the State authority, it would in most cases be sour before it reached its destination, and the results obtained would consequently be less satisfactory than when reached with a fresh sample. Moreover, if milk adulteration is to be prevented, daily inspection of the supply is essential. For this reason the State Boards of Health have done less than local authority toward the suppression of this evil, except in some cities where there was an analyst of the State Board.

The most common forms of milk adulteration are the removal of the cream or skimming, and the addition of water. Occasionally a milk is found which contains a little carbonate of soda, added to counteract some actual or possible souring of the milk; and less frequently a little caramel or burnt sugar to disguise the bluish color consequent upon excessive skimming. As to the long list of unsavory compounds which are given as adulterants of milk, they are very seldom, if ever, met with in this country.

The efforts that have been made in some of our larger cities, notably in

New York, to suppress the sale of skimmed milk have met with vigorous opposition from interested parties. It is claimed that skimmed milk is perfectly wholesome and contains much nutritious substance, that it can be sold in cans properly labelled, and that consequently there is no good reason for prohibiting its sale. No one will dispute the claim that skimmed milk is wholesome; but there are other grounds upon which its sale is prohibited. In the first place there is practically no demand for skimmed milk, and when sold at all it is under the supposition, on the part of the purchaser, that it is the genuine article. Secondly, experience has shown that even though the cans containing skimmed milk are so labelled the milk will not be sold as such. These cans are usually placed behind a counter or in a refrigerator where the label is not visible to the purchaser; and the milk might be placed in another can after reaching the dealer's premises. The labels on the cans are often no better than no labels. In one case where the law prescribed a letter of a certain length the dealer complied in this particular, but made the letters so narrow as to be entirely illegible. Thirdly, in cities large numbers of infants and children are dependent upon cow's milk as food, and when the milk is deprived of its cream it loses a most important element of its nutrition. Fourthly, skimmed milk is about twenty-four hours later in reaching the market than the pure article, and it is consequently so much nearer its souring point. Such milk, taken into the child's stomach, would most probably sour before it could be digested. Granting that skimmed milk could be sold under its true name, and that it contained all the nutrition needed by the child, the fact that it cannot be obtained in a fresh condition would be sufficient reason for our health authorities prohibiting its sale in large cities.

Another form of adulteration, even more serious than the last, is the sale of milk of diseased cows. There are numerous cases on record which prove that the milk obtained from such animals is unfit for food, as it is very liable to produce sickness and disease in those consuming it. Milk may also serve as a carrier of disease when such exists on the premises where the milk is produced.

A word may be said here on the use of the lactometer for detecting milk adulterations. This instrument is merely a hydrometer graduated for milk, and detects certain adulterations which affect the specific gravity of the liquid.

Dinocourt, the originator of the lactometer, fixed upon 1.029 as the minimum density of genuine milk; and the New York City Board of Health, as well as the health authorities in other cities, have adopted the same standard. In graduating the lactometer the 100 mark corresponds to a specific gravity of 1.029, and the 0 mark to 1.000. The intervening space is divided into 100 parts. In testing milk it is cooled to 60° F., and the lactometer is placed in it. If the instrument sinks to the 100 mark the milk would pass as genuine, but if it sinks to 60 we know that the sample consists of at least forty parts of water and sixty parts of milk. The minimum density of 1.029 is below that of the average pure milk; and it is possible, therefore, for the milkman to add, say, ten per cent. of water without its being detected by the lactometer. The skimming of the milk increases its gravity and consequently it stands higher by the lactometer. Water might even be added to the skimmed milk without the gravity falling below 1.029. Such doctoring as this would give a product of an unnaturally blue color, and the absence of cream would also be shown by the appearance of the sides of the vessel contain-

ing the milk. The addition of cream, as well as the addition of water, produces a lowering of the gravity, but we know of no instance where a person has been detected of adulterating milk with cream.

The lactometer, therefore, detects only the grosser frauds practised by milkmen. In some cases a chemical analysis of the milk is necessary; but the time involved in making an analysis is such as to render this means of detecting adulteration impracticable for every-day inspection.

Coffee, Tea.—The adulterations of coffee are for the most part confined to chicory and dandelion roots, peas, hominy, rye, and other cereals. These are roasted and ground, and mixed with the coffee in varying proportions. Sometimes the coffee-bean is slightly coated and polished, and in New York and Brooklyn there are establishments which make quite a business of this. This is clearly an adulteration, for although little or no foreign matter may be added, the polishing is done to conceal damage or make the bean "appear better than it really is, or of greater value."

Of the adulterants of coffee, chicory is the most common; and it is claimed that many persons prefer this mixture to the pure coffee. The addition of chicory, as well as the other substances mentioned, is noticed only in the ground coffee, as its presence in the unground coffee would be very easily detected. The best plan, therefore, is to buy the coffee-bean, either roasted or unroasted, and to grind it as needed. After a little practice, it becomes an easy matter to pick out in the ground coffee particles of chicory, pea, etc. The former are usually soft, and lack the smooth appearance of bits of coffee-bean; while, if peas are present, the outer coating becomes detached, and is easily recognized. When the coffee is ground very fine, a microscopical or chemical examination is often necessary to detect adulteration.

There is nothing unwholesome in chicory, peas, rye, etc., but when they are sold for genuine coffee, wholly or in part, it is a fraud upon the purchaser, and the infusion possesses little or none of the pleasant aroma and taste of the unadulterated article.

The various preparations sold under the names of coffee extracts, coffee essences, etc., consist for the most part of mixtures of caramel, licorice, etc., with usually no trace of coffee in them.

As many persons prefer or are obliged to use some substance cheaper than pure coffee, it would be a needless restriction upon trade to prohibit entirely the sale of "mixtures." The dealer, however, should be required to label distinctly all such mixtures, and sell them for what they really are. In New York State the sale of coffee mixtures is permitted, provided the mixture contains at least fifty per cent. of coffee (see Addenda).

The adulterations of tea consist in the use of exhausted and foreign leaves, in the addition of "lie" or imitation tea and mineral substances, and lastly, in the artificial coloring and coating of the tea-leaves.

"Lie" tea consists of tea-dust, the sweepings of the tea warehouses, etc., made up into small masses of different sizes, with gum or rice-water, and usually colored to imitate genuine tea. It is found in the lower grades of China tea, although not restricted to them, and can generally be picked out without difficulty. From the very nature of the "lie" tea, it is clearly not a wholesome article of food.

The "facing" or coloring of tea is practised to a very great extent with the China-grown teas, and also with those from Japan. The practice has been carried on for so many years that it is doubtful whether the average consumer has any idea of the color of the genuine leaf. The

substances used are Prussian blue, indigo, turmeric, soapstone, and gypsum. It is said to be practised because there is a demand for these highly colored teas, but it is none the less an adulteration. It serves no good purpose in the tea, and the better class of tea merchants and others admit that the tea would be better without it. While no one has ever been known to have been seriously injured by drinking faced tea, the facing is not wholesome.

The passage by Congress, in March, 1883, of a law prohibiting the importation of adulterated tea, has already done much to improve the quality of teas sold here.

Flour, Bread.—So far as examinations of flour and bread have been made in this country they have failed to show any serious adulteration. Occasionally cases are reported of sickness caused by eating bread, but when the matter has been carefully inquired into there usually is sufficient ground for the belief that the sickness was due to certain mould fungi, rather than to any adulteration in the bread itself. From the nature of the case it is impossible to estimate the sickness due to this cause; but while such cases are rare, it is clear that all danger can be avoided by a sufficient amount of care. Damaged flour is doubtless occasionally employed where it should be rejected.

At one time there was great objection raised against the use of alum in bread preparations, but of late years not so much is heard of it. Alum is employed in two ways and for two entirely different purposes. Sometimes it is added to damaged or even to good flour in order to improve the appearance of the bread. This use is certainly objectionable, not so much because the small amount of alum used will do any harm, but because it is used to conceal the defects of a damaged article, and one which in many cases is not fit for food. The second use to which alum is put is in baking powders in combination with bicarbonate of soda. Here it serves merely to liberate the carbonic acid, and in so doing ceases to exist as alum, and is converted into the hydrate of alumina. The objections urged against the use of alum are based entirely upon theoretical grounds, considering it as alum rather than as the hydrate of alumina.

Butter, Cheese, Lard.—The adulteration of butter is carried on to a very considerable extent in this country. Taking New York City as an example, it is probable that if a person should buy butter at every grocery store in the city, fully one-half of the samples would be found to be adulterated. In some cases there is little or no butter present, the sample consisting principally of foreign fat. Most grocers keep more than one grade of butter, the better and higher priced grades often being the genuine article. It is a common thing to see conspicuous signs reading, "Fine Creamery Butter," "Nice Dairy Butter," etc., offered at the price of genuine butter, which on analysis prove to be anything but the real article.

As might be supposed the most common adulterant and substitute is oleomargarine. *Some samples consist of this entirely;* others contain more or less lard; and still others are mixtures of butter and oleomargarine. Statements have appeared to the effect that cotton-seed oil is sometimes used as an adulterant. While this may be so, no cases of this kind have come under our observation, nor do we know of any well-authenticated cases.

Adulteration with an excess of water or salt, or by the addition of other substances is seldom met with.

We are in the habit of eating all manner of fats in our food, in one

form or another, and no one ever thinks of their being more unwholesome than butter. An artificial butter, made of clean fat and in a manner to exclude foreign contamination, has never been shown to be an unwholesome article of food. Persons engaged in the dairy business usually admit this; but they claim, and very properly too, that artificial butter should be sold for what it really is. It is therefore a commercial question, like many others met with in food adulteration. At the same time, as it constitutes a violation of law to sell the artificial for the natural product it is clearly the duty of those charged with the enforcement of the law to see that the fraud is suppressed.

Of late years some manufacturers of oleomargarine have been in the habit of adding a certain percentage of lard, the reason for so doing being generally given that the product does not melt so readily in warm weather. The melting-point of lard is several degrees above that of oleomargarine, and might naturally serve the purpose claimed; and yet one can hardly lose sight of the possible wish to cheapen the cost of manufacture.

The most important adulteration of cheese in this country consists in the substitution of lard for butter fat in the process of manufacture. Skimmed milk is employed, and the fat lost in the cream is replaced by using lard. There is no ground for prohibiting the sale of lard cheese, provided it is sold for what it really is. This is seldom done, however, and the manufacture and sale of whole-milk cheese is greatly injured in consequence.

Lard is sometimes adulterated with water and salt; and numerous statements have appeared to the effect that foreign fats are sometimes substituted in part for that of the hog. It would be a matter of some surprise if there was no foundation for such reports; but the difficulty of establishing the fact of such adulteration has led to quite contrary assertions. The attention which this subject has of late attracted will doubtless lead to more positive information. From the examination of many samples of lard, it is evident that the careless and uncleanly method of rendering sometimes practised results in the production of an article unfit for human consumption.

Canned Foods.—The very general use of canned fruits and vegetables renders the contamination of such foods with tin, lead, zinc, etc., a very important matter. That such contamination exists in many cases is beyond doubt; but there are great differences in the quantities of these metals found. Other things being equal, that can would contain most dissolved metals which had been put up the longest. If the date of preparation were stamped upon each can it would give the purchaser some idea of where he might find most contamination. Aside from this there are certain requirements which should always be observed by the manufacturers of such articles. The tin plate employed should be of the best kind, and free from lead. If the soldering is done with ordinary solder it should never be allowed to come in contact with the contents of the can. The contamination of canned foods with lead is usually owing to the careless soldering of the cover, by which the liquids in the can act upon the solder containing lead. This is supposing that good tin plate, and not "terne" plate is used in making the can. The Director-General of Customs of France has forbidden the use, in the preservation of food, of cans which are soldered on the inside, unless fine tin is employed exclusively for the purpose.

The quantity of tin found in canned foods varies from .1 of a grain to

3 or 4 grains per quart can. It is impossible to say just what the effect would be in the continued taking into the system of small quantities of tin. It does not appear to act as a cumulative poison, but large doses would doubtless be attended with serious results. The small amount of this metal which would be taken by the use of canned foods properly prepared would probably not produce any appreciably injurious effect. Lead, however, acts as a cumulative poison and the use of food containing it should be avoided, whether it be the canned article or that prepared in enamelled vessels containing lead.

A case was recently reported where serious sickness attended the use of cherries preserved in a glass jar having a plain zinc cover. It was found that the contents contained a small quantity of zinc, whereas the same fruit preserved at the same time in jars having glass-lined covers did not contain this metal. The conclusion reached in this case was that it was one of zinc-poisoning.

It is often a fact that in cases of sudden sickness, attributable to some article of food, an examination shows the presence of a foreign substance more or less objectionable, and the conclusion is immediately reached that this substance was the cause. Sometimes the conclusion is reached without any examination; and very often it happens that, if the case is carefully investigated, the alleged cause proves not to be the true one.

Where there is doubt as to the actual cause, such doubt should be expressed, and so avoid arousing public distrust of an article of food which may be in no way responsible for the sickness. Unfortunately, there appear to be certain poisons, noticed more especially in animal foods, of which nothing is known, and which are often the cause of sickness unjustly attributed to some harmless contamination present.

Pepper, Mustard, Spices.—These are notoriously adulterated, and the adulterants employed are often composed of almost anything which can be made to resemble the genuine article. The plea which is always urged when the question of pure spices is discussed is that the consumer does not want the pure article, that in most cases it is too strong. The obvious answer to such an objection is that the consumer can use less of it. We doubt, however, whether the average consumer has ever seen certain condiments in a state even approaching purity. At the same time, if the consumer wants flour in his mustard, and charcoal in his pepper, let him have them, they will never do him any harm; but for the sake of those who prefer the pure articles, require the dealer to label his wares just what they are. It is safe to say that if this were insisted on by a vigorous enforcement of the law, most people would soon decide to do the "adulterating" in their own kitchens.

LITERATURE.—The following are a few of the more important works on food adulteration: Food, its Adulterations, and the Methods for their Detection, A. H. Hassall (1876); Foods, their Composition and Analysis, A. W. Blyth (1882); The Analysis and Adulteration of Foods, James Bell (1881 and 1883); Lexikon der Verfälschungen der Nahrungsmittel und Getränke, H. Klencke (1879); Sanitary Examinations of Water, Air, and Food, C. B. Fox (1878); On Food, H. Letheby (1872); Die menschlichen Nahrungs- und Genussmittel, etc., J. König (1880); Die Praxis des Nahrungsmittel-Chemikers, F. Elsner (1880); Die wichtigsten Nahrungsmittel und Getränke, etc., O. Dietzsch (1879); Nahrungs- und Genussmittel, etc., A. Vogl (1872); Butter, its Analysis and Adulterations, O. Hehner and A.

Angell (1877); Dictionnaire des altérations et falsifications des Substances alimentaires, etc., A. Chevallier et E. Baudrimont (1877); The Analyst, Vols. I.–VIII 1877 to date.

ADDENDA.

The following are copies of the food adulteration law of the State of New York, and the resolutions regarding "mixtures," passed by the State Board of Health:

AN ACT to prevent the adulteration of food or drugs.

[Chapter 407, Laws of 1881.]

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

SECTION 1. No person shall, within this State, manufacture, have, offer for sale, or sell any article of food or drugs which is adulterated within the meaning of this act, and any person violating this provision shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by fine not exceeding fifty dollars for the first offence, and not exceeding one hundred dollars for each subsequent offence.

SEC. 2. The term "food," as used in this act, shall include every article used for food or drink by man. The term "drug," as used in this act, shall include all medicines for internal and external use.

SEC. 3. An article shall be deemed to be adulterated within the meaning of this act—

a.—In the case of drugs.

1. If, when sold under or by a name recognized in the United States Pharmacopœia, it differs from the standard of strength, quality, or purity laid down therein.

2. If, when sold under or by a name not recognized in the United States Pharmacopœia, but which is found in some other pharmacopœia or other standard work on Materia Medica, it differs materially from the standard of strength, quality, or purity laid down in such work.

3. If its strength or purity fall below the professed standard under which it is sold.

b.—In the case of food or drink.

1. If any substance or substances has or have been mixed with it so as to reduce or lower or injuriously affect its quality or strength.

2. If any inferior or cheaper substance or substances have been substituted wholly or in part for the article.

3. If any valuable constituent of the article has been wholly or in part abstracted.

4. If it be an imitation of, or be sold under the name of, another article.

5. If it consists wholly or in part of a deceased or decomposed, or putrid or rotten, animal or vegetable substance, whether manufactured or not, or, in the case of milk, if it is the produce of a diseased animal.

6. If it be colored, or coated, or polished, or powdered, whereby damage is concealed, or it is made to appear better than it really is, or of greater value.

7. If it contain any added poisonous ingredient, or any ingredient

which may render such article injurious to the health of a person consuming it: Provided that the State Board of Health may, with the approval of the Governor, from time to time declare certain articles or preparations to be exempt from the provisions of this act: And provided further, that the provisions of this act shall not apply to mixtures or compounds recognized as ordinary articles of food, provided that the same are not injurious to health and that the articles are distinctly labelled as a mixture, stating the components of the mixture.

SEC. 4. It shall be the duty of the State Board of Health to prepare and publish from time to time lists of the articles, mixtures, or compounds declared to be exempt from the provisions of this act in accordance with the preceding section. The State Board of Health shall also from time to time fix the limits of variability permissible in any article of food or drug, or compound, the standard of which is not established by any national pharmacopœia.

SEC. 5. The State Board of Health shall take cognizance of the interests of the public health as it relates to the sale of food and drugs and the adulteration of the same, and make all necessary investigations and inquiries relating thereto. It shall also have the supervision of the appointment of public analysts and chemists, and upon its recommendation whenever it shall deem any such officers incompetent, the appointment of any and every such officer shall be revoked and be held to be void and of no effect. Within thirty days after the passage of this act, the State Board of Health shall meet and adopt such measures as may seem necessary to facilitate the enforcement of this act, and prepare rules and regulations with regard to the proper methods of collecting and examining articles of food or drugs, and for the appointment of the necessary inspectors and analysts; and the State Board of Health shall be authorized to expend, in addition to all sums already appropriated for said Board, an amount not exceeding ten thousand dollars, for the purpose of carrying out the provisions of this act. And the sum of ten thousand dollars is hereby appropriated out of any moneys in the treasury, not otherwise appropriated, for the purposes in this section provided.

SEC. 6. Every person selling or offering or exposing any article of food or drugs for sale, or delivering any article to purchasers, shall be bound to serve or supply any public analyst or other agent of the State or Local Board of Health appointed under this act, who shall apply to him for that purpose, and on his tendering the value of the same, with a sample sufficient for the purpose of analysis of any article which is included in this act, and which is in the possession of the person selling, under a penalty not exceeding fifty dollars for a first offence, and one hundred dollars for a second and subsequent offences.

SEC. 7. Any violation of the provisions of this act shall be treated and punished as a misdemeanor; and whoever shall impede, obstruct, hinder, or otherwise prevent any analyst, inspector, or prosecuting officer in the performance of his duty shall be guilty of a misdemeanor, and shall be liable to indictment and punishment therefor.

SEC. 8. Any acts or parts of acts inconsistent with the provisions of this act are hereby repealed.

SEC. 9. All the regulations and declarations of the State Board of Health made under this act, from time to time and promulgated, shall be printed in the statutes at large.

SEC. 10. This act shall take effect at the expiration of ninety days after it shall become a law.

Resolutions Regarding Mixtures.

"*Resolved*, That under and pursuant to Section 4 of Chapter 407 of the Laws of 1881, the following mixtures, when distinctly labelled in the manner provided in subdivision 7 of Section 3 of said act, are within the conditions hereinafter prescribed declared to be exempt and permitted to be sold under the provisions of the said act.

"1st. Coffee mixtures containing no other substances except chicory, peas, or cereals, and in which mixtures the pure coffee shall not be less than fifty per cent. of the whole mixture or compound, provided that the exact percentage of coffee be printed upon the label of each package.

"2d. Mustard mixtures with wheat or rice flour, to which no other substance, or article, or any coloring matter, except turmeric is added, and in which mixture the pure farina of mustard shall not be less than forty per cent. of the whole mixture or compound, exclusive of the mustard hulls.

"The labels on the above mixtures shall contain the names of each and every ingredient of the mixture.

"The labels shall also exhibit the percentage of the characteristic constituents; for example, the percentage of coffee in the coffee mixture and the percentage of mustard in the mustard mixture.

"The above-mentioned information shall be printed on the labels in black ink, in legible antique type, of a size easily to be read, on one side of the package."

Approved March 24, 1883.

DISINFECTION AND DEODORIZATION.

By ROGER S. TRACY, M.D.,

Sanitary Inspector of the Board of Health, New York.

The Nature of the Contagia.—The theory that the zymotic diseases are dependent on and are propagated by micro-organisms has been gaining ground recently in America as elsewhere. Dr. Cabell, however, has called attention to the prevalence of typhoid fever in Virginia, at various times, in places where periodic (malarial) fevers had been common, the latter diseases subsiding on the appearance of the former.[1] A similar succession of these diseases has been noticed of late years in New England, and malarial disorders have made their appearance in districts hitherto entirely free from them, but where typhoid fever has been almost endemic. Here also the enteric fever has diminished as the periodic fever has increased. These facts suggest some subtle relation of these diseases to each other, and raise a doubt as to the dependence of either disease upon a specific organism.

In 1875, Drs. Edward Curtis and Thomas E. Satterthwaite made a series of investigations into the pathogeny of diphtheria, but found that very much the same symptoms were produced in rabbits by the inoculation of diphtheritic membrane, scrapings from the human tongue, or Cohn's fluid in a putrescent condition.[2] They found that, after filtering out the particulate matters, the fluid was harmless.

A strong presentment of the micro-organism theory was made by Dr. William T. Belfield, of Chicago, in the Cartwright Lectures, delivered before the Alumni of the College of Physicians and Surgeons of New York, in February, 1883.[3]

Purification of the Air by Chemical Methods.

It is not believed that aërial disinfectants are of any use, except in such quantity as to be destructive of human life. Experiments on the micro-organisms show that they resist the action of poisons and destructive gases in proportions that are fatal to higher organisms. Gases and vapors liberated in a tenanted room must therefore be looked upon only as deodorants. The best of these is probably ozone, which may be added to the air of a room by the methods suggested in the text. The various patented ozone generators possess no advantage, except that of neatness, over a

[1] The Etiology of Enteric Fever, by J. L. Cabell, M.D., Trans. Am. Med. Association, 1877, p. 411.

[2] Report of the Board of Health, New York, 1874–75, p. 657.

[3] On the Relations of Micro-Organisms to Disease, N. Y. Medical Record, February and March, 1883.

simple stick of phosphorus in a saucer of water, and the mechanical devices for discharging the vapor of carbolic acid and other ill-smelling substances into the atmosphere are of no practical value except as deodorizers.

As regards the effect of poisonous solutions on the low forms of organic life, the experiments of Dr. George M. Sternberg, United States Army, show that mercuric chloride (corrosive sublimate) is the most powerful disinfectant we possess.[1] The results given below were obtained by experiments with the micrococcus of gonorrhœal pus, which appeared to resist the germicide agents longer than the other organisms which were tried. After exposure to the poisons the vitality of the germs was tested by introducing them into sterilized *bouillon*.

	Per cent.	Efficient in the proportion of 1 part in
Mercuric chloride	0.005	20,000
Potassium permanganate	0.12	833
Iodine	0.2	500
Creasote	0.5	200
Sulphuric acid	0.5	200
Carbolic acid	1.00	100
Zinc chloride	2.00	50
Tinct. ferri chloridi	4.00	25
Salicylic acid, dissolved by sodium borate	4.00	25

A much weaker solution (from one-half to one fourth the strength above given) was found to prevent further development of the micrococci, and ferric sulphate, which failed in a saturated solution to destroy the vitality of the germs, arrested their development in a one-half per cent. solution. Zinc sulphate was found to have no germicide value in a solution of twenty per cent. The action of zinc chloride and sulphate, and of ferric sulphate in arresting the development of germs seemed to be due to the precipitation of organic matter in the nutritive medium rather than to any direct action on the living organisms.

Purification of Rooms after Infectious Diseases.

By some persons chlorine is preferred to sulphurous oxide for fumigation. For 100 cubic feet of space it would be necessary to use about one-half or three-fourths of a pound of black oxide of manganese, and from three-fourths to one pound of strong commercial muriatic acid; or the same amount of manganese oxide may be used with an equal weight of salt and from one to one and one-half pound of oil of vitriol; or between one and two pounds of chloride of lime with nearly an equal weight of acid diluted with about twice its bulk of water. Sulphurous oxide and chlorine cannot be used together, as they neutralize each other. Any of the above mixtures should be made in an earthen dish large enough to allow for "frothing up." The evolution of the gas is so rapid that it is difficult for a person to make the mixture complete before he is driven away by the fumes.[2]

[1] Experiments to Determine the Germicide Value of Certain Therapeutic Agents, Am. Jour. of Med. Sciences, April, 1883, p. 321. These experiments confirm the conclusions of Dr. Koch, of Berlin. See also an article in the same number of this journal by Dr. J. C. Wilson, p. 345.

[2] Waller: Art. Disinfectants in Buck's Hygiene, vol. ii., p. 555.

Disinfection in Various Diseases.

For disinfection of bed-linen, towels, and body clothing of patients ill with contagious diseases, it has been recommended to use a solution of four ounces of zinc sulphate and two ounces sodium chloride to the gallon of water (practically a solution of zinc chloride).[1] Discharges to be received in vessels containing a solution of ferrous sulphate (one and one-half pound to the gallon). When such articles can be burned, that is the best way to dispose of them. Straw-beds should always be destroyed by fire, and hair mattresses and stuffed furniture should be ripped open and the contents spread out so as to be thoroughly exposed to the sulphurous fumigation. When rags are used about the mouth and nose of the patient, as in diphtheria, scarlatina, or phthisis, they should be immediately burned. Recovered patients should never be allowed to mingle with well persons again, until the body and especially the hair has been thoroughly washed with soap or borax, and cleaned of all scurf.

Isolation of such patients is essential. The sick-room should be visited only by those in immediate attendance on the patient. Ventilation should be brought about by means of an open fire and windows opening to the external air. It has been suggested by Dr. Malcolm McLean, of New York, that the cracks, keyholes, and other openings about doors or windows communicating with other parts of the house should be hermetically closed by pasting strips of paper over them, excepting of course the door of entry, which should have a large sheet constantly wet with a solution of carbolic acid hung over it on the inside.

In view of recent experiments, it would seem that mercuric chloride would be a better disinfectant for use in such cases than the commonly used zinc chloride. Dr. J. C. Wilson[2] suggests that the physician should himself carry this substance with him, and in such cases should put two drachms into a gallon of water, to be used in disinfecting the discharges. This would make a solution of the strength of about 1 to 500. One drachm (1 to 1,000), or even thirty grains (1 to 2,000), would probably answer the purpose, and as the drug costs only fifteen cents an ounce, it is probably the cheapest and best disinfectant in the market, having neither color nor odor.

Local Use of Disinfectants.

Apartments.—Ozone, produced by phosphorus two-thirds covered with water, or by mixing potassium permanganate and sulphuric acid. Fumigation.

Bed-linen, Towels, etc.—Zinc chloride (two ounces to the gallon of water) or mercuric chloride (one drachm to the gallon of water).

Cellars, Outhouses, Stables, etc.—Quicklime sprinkled about. Whitewash. Carbolic acid, strong solution (1 to 100).

Cesspools, Privy-vaults, Water-closets, etc.—Ferrous or ferric sulphate, saturated solutions. Zinc sulphate (two pounds to the gallon) and chloride (one-half pound to the gallon). These latter are better for water-closets, be-

[1] See Instructions for Disinfection, prepared for the National Board of Health by Profs. C. F. Chandler, Henry Draper, G. F. Barker, S. O. Vander Poel, E. G. Janeway, and Ira Remsen. Printed in New York State Board of Health Report for 1881–82, p. 118.

[2] In article previously cited in foot-note, p. 519.

cause they cause no discoloration. The Metropolitan Disinfectant, much used in New York for disinfection of privies, contains half a gallon of dead oil, one gallon of copperas solution (saturated), diluted with water to make three gallons.

A patented apparatus, called the Germicide, is in frequent use in New York for disinfecting water-closets. Every time the closet is used a small amount of zinc chloride is discharged into the pan or bowl, and the vapor of thymol is mingled with the atmosphere of the room.

Corpses, when infectious, should be wrapped in cloth saturated with a strong solution of zinc chloride or carbolic acid, and a pad of sawdust or fine shavings saturated with the same solution placed under the hips, to disinfect discharges.

The bodies of those who have died of small-pox should be buried in air-tight coffins (metallic) and no funeral should be allowed.

Street Gutters, etc.—Ferric or ferrous sulphate. Chloride of lime. The New York Board of Health uses a zinc and iron solution obtained as a by-product in de-tinning scrap-tin plate. It contains about 4½ per cent. of ferrous sulphate, 14 per cent. of ferrous chloride, and 9 per cent. of zinc chloride.

Utensils.—Zinc chloride (two ounces to the gallon). Mercuric chloride (one drachm to the gallon). Potassium permanganate (one ounce to the gallon). The latter salt stains clothing brown.

The Girondin Disinfectant and Platt's Chlorides are in very common use. An analysis of the former, made by Waller, shows the following constituents:

	Per cent.	Oz. in gallon.
Zinc sulphate	19.692	32.64
Cupric sulphate	1.202	1.99
Calcium sulphate	0.480	0.79
Water, traces of calcium chloride, etc.	78.626	130.34
	100.000	165.76

Platt's Chlorides contain saturated solutions in the following proportions:

Zinc chloride	40 per cent.
Lead chloride	20 " "
Calcium chloride	15 " "
Aluminum chloride	15 " "
Magnesium chloride	5 " "
Potassium chloride	5 " "

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VITAL STATISTICS.

By ROGER S. TRACY, M.D.,

Sanitary Inspector of the Board of Health, New York.

It is important to know not only the exact number, if possible, of births, marriages, and deaths in a population, as well as the number of the living, but the value of such statistics is immensely increased, if it can be learned with accuracy what are the occupations, residences, birthplaces, ages, race, etc., of the persons enumerated, as well as the meteorological conditions under which they have lived from day to day. An attempt was made in the United States in 1870 to furnish a complete census of the population upon such a comprehensive plan, but as the time allowed for its completion was only three months, the work was full of inaccuracies. The census of 1880 was conducted on a larger scale, and is expected to furnish a greater body of important facts, with more complete and useful classifications, than any such work hitherto undertaken in the world. The magnitude of the task may be inferred from the fact that, at the present time (October, 1883), more than three years after its inception, the first volume of reports is barely ready for distribution.

The first attempt at registration in this country seems to have been in the colony of Massachusetts Bay, where in September, 1639, it was ordered that births and deaths should be reported to the town clerk by parents and householders within one month. Newly married men were also to give the clerks certificates of their marriage. Similar orders were issued by the Plymouth colony in 1646.[1] Many States at present have laws regarding the registration of vital statistics, but it is so difficult to carry out a law of this character, that the records throughout the country are very imperfect. In 1876, Dr. Bowditch expressed the opinion that no State in the Union, nor the United States as a nation, had any proper system for the registration of vital statistics.[2]

The registration of births and marriages is nowhere complete. That of deaths is believed to be complete, or nearly so, in Boston, Providence, New York, Philadelphia, and Washington. New York, being surrounded by water, is particularly favored in this respect, as the avenues of exit from the city are few and easily guarded. The only way of procuring reports of births and marriages, with any pretension to completeness, seems to be

[1] See paper by Dr. J. S. Billings on Registration of Vital Statistics in Am. Journal of the Med. Sciences, January, 1883. The early history of registration in the United States is given by Dr. Sutton as an appendix to the Second Annual Report of Births, Marriages, and Deaths in Kentucky for 1853. He gives nearly all the State laws on this subject in an appendix.

[2] See Dr. H. I. Bowditch's Essay on Public Health in America. Boston, 1877. Quoted by Dr. T. B. Curtis, in Buck's Hygiene, vol. ii., p. 307.

the rigid and impartial enforcement of penalties in cases of non-compliance with the law.

In the case of reports of death and sickness, absolute accuracy is impossible of attainment. The cause of death is always a matter of opinion, and although opinions may agree in the vast majority of cases, there will always be a sufficient number of deaths in which the cause is extremely doubtful, to vitiate any conclusions that can be drawn from the mortality returns, except relative ones.

In a comparison, therefore, of the deaths and diseases of one period with another, of one locality with another, of one occupation or age, or condition in life with another, of one season with another, will be found the only practically useful conclusions which the hygienist can draw from such data. Under the law of averages, the limits of error and the causes of error will vary with considerable regularity—there will always be about so many faulty diagnoses, so many intentionally false returns, so many omissions to report—so that, even with admitted gross inaccuracies which can never be entirely eliminated, our present statistics properly handled may teach practical sanitarians many useful lessons, especially with regard to the causes affecting the health of small districts.[1]

[1] For comparatively full discussions of these subjects see Vital Statistics, by Dr. T. B. Curtis in Buck's Hygiene; Report of 9th United States Census (Vital Statistics); Essay on Registration, by Dr. C. F. Folsom, in 8th Report of State Board of Health of Mass.; Report on Registration of Prevalent Diseases, by Dr. F. W. Draper, in 7th Report of Mass. Board of Health; Essay on Vital Statistics, by E. B. Eliott, Proceedings of Am. Association for the Advancement of Science, 1856. See also papers on Vital Statistics, by Dr. J. S. Billings, in The Sanitary Engineer, October 4, 1883, et seq.

SOME HINTS TO SANITARY INSPECTORS.

By FREDERICK N. OWEN.

The following suggestions for the sanitary examination of buildings or localities are designed for the use of local health officers and those who, in the capacity of family physician, may be called upon to examine into the cause of outbreaks of contagious or infectious diseases; and although by no means exhausting, the subject may, by directing the attention of the inspector to some of their more prominent causes, enable him to elaborate other lines of investigation which will lead him to a solution of the problem.

Before beginning an examination of a building or locality which is thought to be, or is complained of as being in an unsanitary condition, the inspector should, first of all, by careful questioning of inmates, neighbors, and others, not excepting children, strive to obtain evidence of offensive odors, disagreeable taste of drinking-water, and the like, that will give him something tangible to work upon. He will often find that this testimony will be uniform in a certain direction, and will save him much time and labor in the investigation he is about to make, by directing his attention to some one point as the probable cause of the trouble. For example, if offensive odors are noticed only when the wind is from the east the inspector would do well to begin his search for the nuisance in that direction.

After having satisfied himself of the nature of the complaint the inspector should note the character of the inmates of the house or houses; their cleanliness, modes of life, dress, occupation, and the like. These points will all give him a general idea of the predisposition of the family to disease, and will sometimes account for the immunity from disease of certain members of a family or a whole household during an epidemic.

Should any one in the house be ill, a diagnosis of the case should be made; and if the disease is found to be preventable, the family physician should be consulted, and all points bearing on the case, such as hereditary or constitutional trouble should be carefully noted. If the beginning of the period of incubation of the disease corresponds with the residence of the patient at some other place than that where the disease appeared, it is safe to assume that the poison was taken into the system at that place. Illness often is developed in a family during the early autumn which has been contracted during the summer in some unhealthy locality. When the cause of disease has been traced in this way to some remote place, the detailed examination of the premises where the person is ill, is of course unnecessary. In cases of oubreaks of contagious diseases the first point to be learned is the date of the first appearance of the disease in the community, after which every condition of food, drink, exposure, intercourse, sewage, and the like, should be thoroughly investigated. In case of illness among children who have attended the same school the school-building should be thoroughly examined.

After having made in this way what may be called the *personal* part of the examination, and obtained all the information possible, the attention of the examiner should next be directed toward the location and surroundings of the houses in which the disease shows itself. In the case of isolated country-houses the character of the soil on which it stands, viz., sand and gravel, rock, or clay, is an important factor in its salubrity. Rain falling on the surface of a sandy soil sinks rapidly into the ground and renders the site of the house comparatively dry. Clay and rock, on the other hand, being impervious to moisture, water, in sinking through the top soil and coming in contact with them, flows along their surface to some lower point. In this way inequalities in substrata, or fissures in the rocks acting like great bowls, retain large bodies of water, and should a house be situated directly over one of them render it damp and unhealthy. Situations at the base of hills are particularly unhealthy, as the ground water coming from the higher lands is checked in its flow by the sudden change in the grade, and forced to the surface, making the soil more moist than at any other point.

Trees, too, near a house are unhealthy for several reasons: 1, they cast a shade on it and render it damp; 2, they prevent the free circulation of air about it; 3, in the autumn the dead leaves lying on the ground and rotting give off an odor which is considered quite unhealthy.

Neighboring streams, ponds, and marshes sometimes exert a very bad influence on the health of a household or community. The presence of stagnant water is always to be looked upon with suspicion, and measures aimed at its removal should be recommended. Especially is this the case where, from any cause, the level of the water is liable to fluctuate, at times covering the banks, and again leaving large areas exposed. Malaria is generally a companion to these conditions, and will be found to decrease when proper drainage is instituted, and the water-level is made unvarying. In some instances small streams which have received sewage, have been known to carry typhoid contagion to persons in districts through which they flow by the drinking of the water thus contaminated. Although streams so polluted become again fit for drinking by the oxidation of their impurities, it is still a mooted question at just what distance below the point of contamination in the course of a stream its water again becomes wholesome. It is, therefore, best to examine streams as far up as possible when there is any likelihood of their being, or having been used for drinking at the place under examination. Too much attention cannot be bestowed on the wells of the district, and a thorough study of all possible sources of contamination should be made, in addition to the analysis of the water by a competent chemist. A quantitative analysis in all cases is to be preferred, as the examiner is able by it to determine with greater accuracy the probable cause and recentness of the contamination.

The inspector should provide himself with a note-book in which he should record all facts learned by questions and observations, together with sketches of the location, and arrangement of the buildings, their water-supply, plumbing, drainage, etc. Never trust to memory. Enter every little item, no matter how seemingly unimportant. The writer has been saved many an awkward predicament by having every detail jotted down. Besides this, the inspector can much more readily grasp the case, and be able to make an intelligent report by this attention to small matters. When on the ground, time should not be considered an element in the problem. What is required is an absolute mastery of the facts, no matter how long it takes; and in some cases it may take days and even weeks.

Although it has already been suggested that every person who is at all likely to throw light on the subject should be questioned before beginning the examination, the inspector never should accept as a fact any statements that may be made by them ; but should always and only depend on the evidence of his own senses.

After having thoroughly studied the surroundings, attention should next be directed to the dwelling. And here at the outset household dirt should be recognized as an important factor in its healthfulness. The dust that accumulates on walls and furniture, and is swept from the floors, would, if sprinkled over the patients in the surgical ward of a hospital, induce such a condition of the wounds as would endanger life. Soiled clothing, slop-pails, garbage barrels, the use of the water-closet as a slop-sink, etc., are all sources of foul odors. The inspector must expect discouragement from the inmates when investigating the habits of the family. They will generally try to shield themselves, and will often be quite incensed at the mere suggestion of their being the cause of the trouble, and will censure their landlord or neighbors.

The various points to notice indoors, are :

I. *The Dryness of the Air.*—This may be judged by the sensation on going suddenly into the cellar. If it is noticeably damp it may come from one of several causes : first, the cellar may be acting like a drain, catching the ground water that flows into it from all sides ; second, the rain-water leader may be broken, discharging the water into the ground and allowing it to percolate into the cellar ; third, the water-pipes may have burst ; fourth, the drain may be broken. During the greater part of the year there is a constant upward current of air in buildings, which creates a partial vacuum in the cellar, sucks in air from the surrounding ground and distributes it through the house. As the cellar air is dry or damp, so will be that of the house ; and great care should be taken to discover the cause of any moisture there may be noticed about the walls or floor. A wet and dry bulb hygrometer, such as is used by the Coast Survey, is an admirable instrument for rapid determination of the humidity of air, and of course much more accurate than mere bodily sensation. A humidity of 60, saturation being 100, should be considered the limit for healthy dwellings in this country.

II. *The Mode of Heating the Building.*—Where hot-air furnaces are used, the position of the air inlet and the condition of the ducts should be carefully examined. Cracks or openings in the fresh-air duct, or the position of the air inlet near a drain opening, or other source of contamination will allow foul air to pass into the heating chamber of the furnace and be distributed through the house.

III. *The Means for Ventilation.*—As a rule American houses have no other way of changing the air than by opening the windows. Water-closets oftentimes are found with no connection with the outer air, located in the middle of the house, and what ventilation there is, is into the rooms of the house.

IV. *The Plumbing and Drainage.*—Unfortunately in most buildings, the pipes are so hidden behind wood-work and under floors, that it is impossible to examine them without calling in carpenters and subjecting the family to great inconvenience. A thorough examination cannot, however, be made without exposing the plumbing to view, and no positive statement of its condition ought to be made on merely a cursory inspection. The plumbing system in any building is very much like a broom, standing on end, with the handle in the cellar. The inspector will therefore, find his work greatly

simplified, by beginning with the trunk lines of pipe and following out the branches, making an off-hand sketch as he goes from floor to floor, showing the positions of the various fixtures, the arrangement of the pipes and their points of junction with each other. Too much care cannot be taken in examining the pipes for imperfect caulking of joints, open connections, putty joints, holes plugged with corks, rag patches, spots of corrosion, and the like.

The fixtures should be examined and their traps tested in order to learn their efficiency as barriers against the entrance of sewer air. To make these tests, as great a pressure should be brought to bear on the traps as there is a possibility of their being subjected to when the plumbing is in constant use. To do this, all the basins, baths, and other fixtures above the traps to be tested and on the same line of piping, should be filled with water and then discharged simultaneously, care being taken that all the pipes are free from obstruction. The fixtures below the trap should then be filled and discharged in the same way. If the trap retains its seal under these tests, it is safe to assume that it is an effectual barrier to the entrance of sewer-air into the building. Every trap should be tested in this way, and a note made of the result.

Pin-holes or air-holes which it is impossible to see with the naked eye, often occur in pipes, and it is therefore best to supplement the examination by a test by which these defects may be detected. For this purpose some volatile substance, like the oil of peppermint, is used, which being introduced into the piping of a building, finds its way through any defect and is immediately detected by its penetrating odor. To make the test: pour into the top of the pipe, or, if the pipe does not extend through the roof, into the highest fixture, a pailful of boiling water, then half an ounce of the oil, followed by another pail of hot water. The hot water sent down before the oil warms the pipes and prevents the oil from clinging to them. That sent after it tends to volatilize the oil and carry it into every part of the system. Great care should be taken in handling the oil, as a drop will scent the whole building and destroy the test. It is therefore better for two persons to make it; one to handle the oil, and the other to search for traces of it throughout the house. The former should in no case come down into the house until the whole system of piping has been examined by the latter as a very little of the oil on his fingers will impregnate the dwelling. It sometimes becomes necessary to resort to other methods of testing than that by the oil of peppermint, as for instance, when it is impossible to introduce the oil into the pipes without danger of the odor getting out into the house. In such cases the *smoke test* is sometimes used. While the peppermint is applied at the top, the smoke test is applied at the bottom, and is made by forcing smoke up the drains and pipes by means of a small fan blast. If any imperfections occur in the pipes, the smoke is forced out and is readily detected. The fan should be connected with the pipes at the lowest possible point and before applying the test, all openings known to exist and through which the smoke might be discharged, should be carefully closed.

A list of defects in the plumbing and drainage of houses that have been encountered by a firm of English engineers has been slightly altered to meet American practice, and is given below as being a concise statement of the experience of the writer: 1. Common brick sewers with flat bottoms, under or near houses. 2. Earthen-pipe drains, either broken or with leaky joints, laid under the cellar floor, saturating earth with sewage. 3. Pipe drains, either earthen or iron, laid under houses without sufficient

fall, or with the fall the wrong way. 4. Drains, both earthen and iron, without running traps, admitting air from sewers or cesspools to the pipes in the house. 5. Drains without a free current of air moving constantly through them. 6. Rat-burrows from built drains or sewers undermining flags and floors, and admitting foul air to the house. 7. Rat-burrows worked alongside perfect pipe-drain from street sewers and into houses. 8. Defective connections between soil- or waste-pipes and sewers, admitting foul air to houses. 9. Soil- or waste-pipes without any or sufficient ventilation. 10. Defective water-closet apparatus. 11. Water-closet cisterns with overflows joined to soil-pipe or drain. 12. Safes under closets or basins connected to soil-pipe or drain. 13. Two or more fixtures with unventilated traps on the same line of pipe, siphoning each other when used. 14. Sink overflow-pipes joined to soil-pipes untrapped or with trap liable to siphon. 15. Overflows from basins or baths connected with waste-pipe on sewer side of trap, admitting foul gases to rooms. 16. Water supplies to sinks taken from water-closets or other contaminated cisterns, and used by careless servants for drinking purposes. 17. House cisterns and tanks with overflows direct into soil-pipes or drains. 18. Traps of every description without ample ventilation to prevent them from siphoning. 19. Scullery sinks connected direct to drains admitting foul air to houses, not only through traps, but through joints of brick-work all round, as shown by the smoke test. 20. Bell traps with loose covers on scullery sink connected to drains. 21. Gullies or traps in sculleries, laundries, larders, refrigerators, etc., connected to drains usually dry and untrapped. 22. Rain-leaders used as ventilators to drains, delivering foul air to bed-room windows, or under eaves or roofs. 23. Ash-pits near larders and pantries; ash-pits liable to soak foul moisture through house-walls. 24. Defects of drainage and rat-burrows from neighbors' houses. 25. Water-cisterns in areas near ash-pits or sculleries, and with overflows direct to drains. 26. Wash-basins in dressing-rooms connected directly in any way to drains or soil-pipes. 27. Cisterns of all kinds in houses with overflow connected direct to drains. 28. Cesspools near houses, and cesspools or defective drains near wells. 29. Neighbors' drains crossing under houses, or joining drains.

If an outbreak of contagious or infectious disease is being studied, and up to this point the inspector has not reached any conclusion as to its cause, it would be well for him to examine the food used in common by the families in which the disease occurs. Milk has so often been the carrier of contagion, that everything which in any way could affect it should be carefully examined: the dairy from which it comes, the cows, the milk cans, the water they are washed in, should all receive attention. Then again, the ice may be the cause of the trouble. Impure water in freezing does not make pure ice, and hence the pond or other sources from which it is taken should be examined for any possible cause of contamination.

Many more lines of investigation might be suggested; but space will not admit of their being mentioned. Hundreds of points can only be learned by experience, and all that can be claimed for this article is what its title imports—Some Hints to Sanitary Inspectors.

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